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DECEMBER 8.

British Foundrymen's Association: Birmingham Branch :—"Grey Cast Iron," by J. E. Hurst.
British Foundrymen's Association: Scottish Branch :—"Cupola Notes," by R. R. McGowan.

DECEMBER 14.

British Foundrymen's Association: London Branch :—"Refractories and Foundry Facings," by H. Winterton.
British Foundrymen's Association: Sheffield Branch :—General discussion.

NOTES AND COMMENTS.

Conjoint Board of Scientific Societies.

The future progress of industry will depend so much on the activities of our scientific and technical societies that we view with interest the report upon its aims, objects, and results of the first year's work, 1916-1917, recently issued by the Board of Scientific Societies. It states, *inter alia*, that on March 22, 1916, at the instance of the Council of the Royal Society, a conference was held with representatives of the leading Scientific Societies, at which the following resolution was passed:—"That it is desirable to establish a Conjoint Board of Scientific Societies for the purpose of (i) promoting the co-operation of those interested in pure or applied science; (ii) supplying a means by which the scientific opinion of the country may, on matters relating to science, industry, and education, find effective expression; (iii) taking such action as may be necessary to promote the application of science to our industries and to the service of the nation; (iv) discussing scientific questions in which international co-operation seems advisable." A Committee was appointed to draw up a scheme in order to give effect to the resolution, and the scheme so prepared was submitted to, and formally accepted at, a second conference held on June 12, 1916.

The President of the Royal Society shall; *ex officio*, be the Chairman of the Board, which shall, in the first instance, consist in addition of four representatives of the Royal Society, together with two representatives of each of the following societies:—The Royal Society of Edinburgh, the Royal Irish Academy, the Royal Society of Arts, the Royal Agricultural Society, the Royal Anthropological Society, the Royal Astronomical Society, the Royal College of Physicians, the Royal College of Surgeons, the Royal Geographical Society, the Royal Institution, the Institution of Chemistry, the Institution of Civil Engineers, the Institution of Electrical Engineers, the Institution of Mechanical Engineers, the Institution of Mining Engineers, the Iron and Steel Institute, the Institution of Naval Architects, the Society of Chemical Industry, the British Association, the Chemical Society, the Geological Society, the Linnean Society, the London Mathematical Society, the Physical Society, the Physiological Society, and the Zoological Society.

The Executive Committee, appointed in the first instance by the Royal Society, consisted of the following members:—Sir Joseph J. Thomson (Chairman), Prof. Herbert Jackson (Secretary), Dr. Dugald Clerk, Sir Robert Hadfield, Mr. A. D. Hall, Sir Alfred Keogh, Sir Ray Lankester, Prof. A. Schuster, Sir John Snell, Prof. E. H. Starling, Lord Sydenham, Mr. Richard Threlfall. On the resignation of Prof. Starling at the end of 1916, Prof. W. W. Watts was nominated in his place, and the last-named was appointed Secretary to the Committee and to the Conjoint Board on the resig-

nation of Prof. Jackson from those offices. Prof. Jackson was appointed Vice-Chairman of the Executive Committee.

The following Sub-Committees have been appointed, and the majority have already presented final or interim reports:—(1) The International Catalogue Sub-Committee. (2) The Sub-Committee on the Application of Science to Agriculture. (3) The Sub-Committee on National Instruction in Technical Optics. (4) The Watching Sub-Committee on Education. (5) The Sub-Committee on the Prevention of Overlapping among Scientific Societies. (6) The Metric System Sub-Committee. (7) The Anthropological Survey Sub-Committee. (8) The Iron-ore Sub-Committee. (9) The Sub-Committee on the Water-power of the British Empire. (10) The Sub-Committee on Timber for Aeroplane Construction.

A Sub-Committee on the Prevention of Overlapping among Scientific Societies was formed to consider and report upon a working scheme for spreading information as to Papers read or about to be read before the various Scientific Societies. The members are Sir Dugald Clerk, Sir Robert Hadfield, Sir Thomas Holland, Mr. E. B. Knobel and Sir Richard Threlfall. The Sub-Committee has held one meeting, at which a Memorandum drawn up by Sir Robert Hadfield was discussed. Sir Thomas K. Rose has been added to the Sub-Committee.

The report indicates that valuable work is in hand in regard to iron ore and other matters, and great national benefit may be looked for as the result of this co-ordination of effort. Viewed from the sectional standpoint of the foundry trade, however, there would appear to be room for work of a more specialised foundry nature than any of the Board's sub-committees is likely to be able to conduct. Founding bristles with problems of a scientific nature, and a special committee to coordinate the work of the many branches of research that have a bearing on founding would prove invaluable. Whether such a committee would operate better under the auspices of such a Board as that abovementioned or under the more direct control of a metallurgical society is an open question; but the need is great and awaits the initiative and energy of professional foundrymen.

Technical Progress in Germany During and After the War.

A German "Union of Technical and Scientific Societies" has recently been formed by the combining of thirteen Associations and Unions to establish a balance between science and practice. Many a technical task, the Chairman of the Union said, could not be carried through without the collaboration of several branches of science. The technical world ought to be represented more than was hitherto the case in the legislative bodies. The Union had also applied to the authorities with a view to being consulted in the preparatory work of drafting regulations or enactments, but hitherto the Imperial Treasury alone had availed itself of their advice in the preparatory work for the taxation of coal and sources of energy.

Professor Wiedenfeld (Halle) showed in a very exhaustive manner how, in former days, Germany could manage well with her own production; how subsequently she became more and more dependent on foreign countries owing to the increase of her population, and was then subjected, by the blockade, to the necessity of producing from her own resources raw materials and food. Technical science could only meet these new requirements by disregarding the questions of cost which formerly, in competing with other countries, was necessarily one of the foremost considerations. Although not all these new conditions and products could be carried over into the times of peace, nevertheless the old economic conditions could not be reverted to; nor would this be even desirable. Technical science had been endeavouring to come to their aid in a three-fold manner:—(1) By procuring the raw materials formerly obtained from abroad, partly by the re-establishment of industries which had become unremunerative such as manganese ore mining, production of sulphur, intensification of agriculture. (2) By promoting the increased utilisation of waste products. The term "non-utilisable substance" has been eliminated by the war. The speaker emphasised in this respect obtaining lubricants from coal tar, and supplying enough requirements of clothing by utilisation of waste material. (3) By producing substitutes, such as for instance nitrogen from the air, and the production of substances by synthetic processes. In his (the speaker's) opinion, too much regard had been paid during the early part of the war to quality; which, however, became impossible with the continued duration of the war.

New Coke Order.

In pursuance of the powers conferred upon him by Regulation 30a of the Defence of the Realm Regulations, the Minister of Munitions has made an Order dated November 27, 1917, that the war material to which that regulation applies shall, on and after September 17, include metallurgical coke of the following classes and descriptions:—

Scottish, Lincolnshire,
Nottinghamshire, Cumberland.

With reference to the above Order, the Minister of Munitions gives notice that the General Permit of November 1, 1916, under the Orders of July 7 and October 31, 1916, shall, on and after September 17, 1917, take effect as if the war material referred to in the above Order of November 27, 1917, were included in the Order of July 7, 1916, and the undermentioned materials and prices were specified in the schedule to the said General Permit, the prices where the material is already specified in such schedule to be in substitution for the prices contained in such schedule, and as if the references to South Yorkshire and West Yorkshire blast furnace coke in the said schedule were cancelled; provided always that condition 2 of the said General Permit shall not apply to any sale or purchase of any of the undermentioned materials under a contract in writing entered into prior to September 17, 1917, at a price not contravening that permitted up to that date.

Maximum prices above referred to for metallurgical coke:—

	£	s.	d.
Durham and Northumberland blast furnace coke	1	13	0
Ditto foundry coke	1	18	0
South Wales and Monmouthshire blast furnace coke	1	17	6
Ditto foundry coke	2	10	6
Lancashire, Staffordshire, Yorkshire, Nottinghamshire, Derbyshire, Lincolnshire, Midland Counties blast furnace coke ...	1	12	0
Scottish blast furnace coke	1	15	0
Ditto foundry coke	2	5	0
Per ton net f.o.t. makers' ovens.			
Cumberland blast furnace coke	1	17	9
Delivered West Coast blast furnaces.			

Electric-Furnace Facts and Practice.*

The following notes relate to the practice with a 3-ton Héroult furnace at the London Foundry Company, Brimsdown. The furnace is run by alternating current, and has power transmitted from a local power station at 10,500 volts. It is a 3-phase furnace, and there are three 200-kw. transformers of the Berry type transforming current down to 80 volts. On each transformer are attached copper cables all clamped together, and kept long enough to allow the furnace to tilt forward when required for emptying. From the cables the current is passed along to the copper bus-bars which are attached to gunmetal holders carrying amorphous carbons 14 in. diameter. The mechanical arrangements of the furnace are very simple, as the tilting is done by a 12-h.p. motor, attached to which is a driving shaft with bevel pinion which drives a screwed shaft inside a nut with an internal thread. The tilting of the furnace is worked by a controller, so that it can go forward or backward into position again.

The holders are of the hinge type with screw in front, which allows the electrode to be fixed tight to prevent slipping, and also to make good contact and prevent arcing. The electrodes are worked by a motor up or down according to requirements; or the motor can be put out of gear and the electrodes worked by hand, as they are on a rack system.

The furnace itself is a simple plated shell on rockers which fit into recesses for studs to prevent the furnace from slipping when tilting backward or forward. Most important is the lining of this shell. The materials used are firebricks, magnesite bricks, silica bricks and dolomite. The magnesite bricks should be near the following composition:—Magnesia, 85.96 per cent.; iron, 7.98 per cent.; alumina, 3.82 per cent.; silica, 1.44 per cent.; alkalies, 0.80 per cent.. The silica brick should be:—Silica, 95.10 per cent.; alumina, 1.80 per cent.; iron oxide, 0.60 per cent.; lime, 2.0 per cent.; magnesia, 0.20 per cent.; alkalies, 0.50 per cent.

Raw dolomite, which is a magnesian limestone, to be good dolomite should be near the following composition:—Calcium carbonate, 53.44 per cent.; magnesia, 44.19 per cent.; alumina, 0.60 per cent.; silica, 0.75 per cent.; iron oxide, 0.68 per cent.; water loss, etc., 0.34 per cent. These are the analyses of material supplied by General Refractories, Kelham Island, Sheffield.

We will first discuss the furnace being worked basic, with dolomite and magnesite. To line the furnace the entire bottom is bricked with firebricks on edge, care being taken to see that every brick is bedded on to the shell. All joints in this layer should be of fine fire-clay, and so close that the bricklayer cannot get the point of his trowel between. After the firebrick bottom is in, bricking the sides is commenced with magnesite bricks, all joints being made of ground magnesite and hot tar mixed over a fire and used hot, dipping the brick face used for the joint in hot tar. Care should also be taken to have good joints if the furnace is to have a good run. The magnesite bricks are laid about two layers above the sill of the furnace, and after all the magnesite bricks have been laid silica bricks follow. These are not so expensive as magnesite bricks, and as they are out of the way of the basic slag they answer the purpose very well. The joints are made with silica cement ground very fine, so that when the furnace gets hot all the silica part of the lining fuses together and forms a solid block. The silica lined part of the furnace is brought up to about 1 in. from the top or level where the roofing fits. This allows a layer of ganister or silica cement to be put on, so that when the roof is put into position it beds itself and makes a good joint. The roof has four lugs, which fit on to cotter pins, so that when cottered up it does not slip during tilting.

The dolomite bottom of the furnace is the most important part of the lining. The dolomite must be quite fresh, for being a calcined magnesian limestone it perishes in a damp atmosphere. It is useless to use any that has gone nearly to powder. The dolomite should be purchased rough and a small crusher installed to crush it as required to pieces about ¾ in. mesh. When crushed it should be spread out on a large plate over a fire, and if there is no mixer available about two barrowfuls at a time should be worked by turning it over continually until nicely warm. It should then be mixed with hot dehydrated tar, using one pint of pitch to two gallons of tar. The tar should be just simmering before being used, and the mixing of the dolomite should be watched to see that enough, but not too much, tar is put in to bind it. The mixture should be turned over and over while on the hot plate to make sure the dolomite is thoroughly mixed.

The next thing is the ramming of the bottom of the furnace. The firebrick bottom should be tarred with a stiff brush, the warm dolomite put into the furnace and rammed by hand with hot rammers (the heads of which should be 6 in. round by 1 in. thick) in layers of about 2 in. to 3 in. at a time. Men for this work of ramming should be strong, as the bottom has to be rammed very hard indeed—the harder the better to get good results. Once ramming the furnace bottom is started it should not be stopped until completed. If not properly done the bottom may only last a few days before it begins to come up in flakes—so badly perhaps as to necessitate shutting down the furnace for a new bottom.

Considering next the roof of the furnace, this is simply a ring with an internal flange about 3 in. wide. The roof is placed on a wooden template with three round holes about 14¼ in. dia. to take round plugs, so that when the bricks are placed round they form three round holes where the electrodes pass from the holders through the roof on to the charge of scrap. The roof is not flat but arched about 2½ in. to the centre. The material used for the roof is the best silica bricks, and should last the life of the furnace brickwork. When bricking the roof, pieces of hard wood the length and breadth of a brick are laid between the bricks at about every three bricks to allow for expansion. Without this precaution the ends of the bricks would chip. Between the bricks is put fine silica cement, with the joints kept very close and the bricks well bedded to one another. Finally, well-mixed silica cement is used to make the outside of the roof airtight by covering it all

* Read, November 16, before the London Branch of the British Foundrymen's Association.

over. Then when the furnace gets to a temperature of about 1,600 deg. C. the roof has no outlets between the brickwork except where the electrodes pass through. The whole of the roof frits together and forms a solid mass of silica. If the silica bricks are good and the furnace worked correctly the roof should last about six weeks of continuous running day and night without any trouble.

When the roof is placed in position it should be laid on a joint of ganister. As the furnace has water coolers around the electrodes, these should be

FIG. 1.—STEEL CASTINGS READY FOR ANNEALING.

placed in position before the roof is lifted from the template. A straight-edge is next required to set the holes in the roof in line with the holders, so that the electrodes pass without touching the roof into the furnace. A man must go inside the furnace to make sure a good joint is made between the furnace walls and the roof. The cotter pins should be slack so as to keep the roof in position, but not be too tight to allow for expansion. Old disused carbons that are too short or unfit for use should be broken up into pieces about 5 in. to 6 in. mesh and laid all over the bottom of the furnace. The electrodes should then be put into position and current put on the broken electrodes by contact, making sure that even heating is got all over the furnace bottom. If contact cannot be got by reason of the pieces not touching, they should be adjusted by a long piece of wood. The dolomite being a conductor, the bottom soon begins to heat; but not more than 200-kw. current should be used for the first hour or two; after that the current should be shut off for one hour to let the furnace heat up slowly. During the next two hours the power should be gradually increased to 300 to 350 kw., and then shut down for another hour to allow a soaking heat. For the next two hours the current should be 400 to 450 kw., and so on, till during the last hour it should be 500 to 600 kw. to frit all the bottom of the furnace and burn all tar out of the dolomite. The heating up of the furnace, to get good results out of the lining, should take from eight to ten hours. When ready all broken carbon is raked out, and the furnace well cleaned, for if any pieces of broken carbon are left in, trouble is experienced by carbon getting in the steel.

Next comes the charging of the furnace, for the lining of the furnace depends upon the charge for protection. As an example of improper charging the following instance may be quoted:—The furnace was charged up to the level of the sill or bottom of the door of the furnace, and the charge was melted down before any more was added, the power being left on while charging and thus involving risk of breakage to the electrodes, which are fragile. The banks or sides of the furnace were left bare, and the whole surface was like a mirror reflecting on the roof; the furnace sides began to run and the roof began to run by being exposed to the heat. The sides, being basic material, were attacked by the acid material running into them and cutting away the banks. It is like pouring hot water on ice to allow acid material to run to the basic bottom, and shortens the life of the furnace very much. This generally results in all sorts of suggestions being made as to improperly manufactured bricks, or bricks of inferior quality, but the trouble does not result from the materials.

The proper charging of the furnace should be as follows:—Lime first; iron ore next, if any; heavy scrap next, care being taken to keep it out of the way of the electrodes when melting; next the turnings, which should be spread all over the furnace bottom, as much turnings being put in as possible and levelled down—it does not matter if they are a foot above the door level, they afford

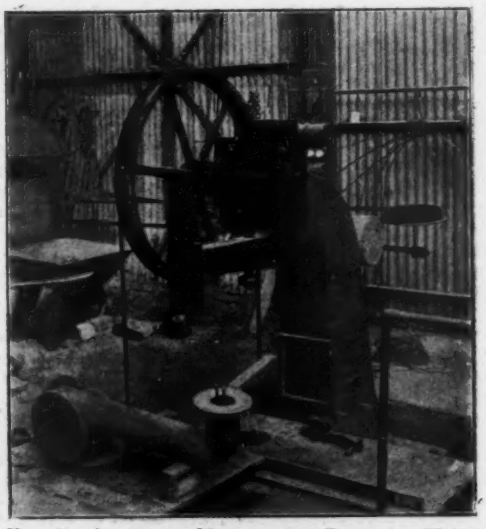


FIG. 2.—ADAPTABLE MACHINE FOR REMOVING HEADS.

better protection to the lining. The 3-phase Héroult type has three electrodes, and melts all the centre away first, leaving a crust all round the banks and sides, so the lining is protected for a long period. When the bath is oxidised the remaining crust is pushed in, and after about 10 minutes the bath is ready for taking off the dephosphorising slag. The bath must be very hot before taking off the first slag, so after slagging off, the high current for finishing the steel is not required.

As this part of finishing only takes from 20 to 30 minutes, the backs and sides are only exposed to the high temperature for that time. The steel should always be finished as quickly as possible. When the steel is poured out the first thing to do is to repair any little defect in the banks, using crushed dolomite.

The writer used to wonder whether the electric furnace was as good as other processes such as the Siemens, Tropenas, Stock oil-fired converter, but time and results have shown the electric furnace to be a first-class furnace. If scrap can be bought at a fair price, whether it be mild steel, nickel steel, or nickel-chrome scrap, such as turning scrap, one can make the finished article at a very reasonable figure if power is reasonable too. It is necessary to remember that all the nickel is retained in the scrap and a large amount of the chrome can be saved, or the latter can be reduced to nil if not wanted. As a reducing furnace there is no better for reducing carbon, silicon, manganese, chrome, sulphur and phosphorus. When making high-class steels a good laboratory is necessary. The scrap is reduced to a practically pure iron, such as :—0.09 per cent. carbon, 0.08 per cent. silicon, 0.01 per cent. phosphorus, 0.09 per cent. manganese. If a bath sample is taken from the furnace and charges are weighed correctly and decent scrap used, allowing for 8 per cent. melting loss, one can make steel to any analysis. We make all kinds of alloy steels in ingots and castings. We have turned out 360 tons a month at a power consumption of 660 units per ton of saleable steel. Our average is well over 80 tons per week, and we often charge, as the furnace gets larger, 4 tons at a time, and complete it into steel in four hours. The cost of steel, of course, depends on the selling price of scrap and other alloys used.

The acid-lined electric furnace is coming into action very quickly on account of the abundance of shell turnings available; it is a little quicker than the basic owing to not being able to refine the charge right up.

Discussion.

At the conclusion of the Paper the author remarked that 3-phase electric furnaces now being put down were far superior to single-phase furnaces. He also quoted the following tests of steel castings produced by the London Foundry Company :—

Physical Tests of Steel Castings made by London Foundry Company, Brimsdown, for Ransomes and Rapier, Limited, and Test by J. S. G. Primrose, Ipswich :—

Heat treatment.	Tons per sq. in.		% Elongation on 2".	% Reduction of Area.	Brinell hardness No
	Elastic limit.	Tensile strength			
Cast and annealed F S.	16.9	33.6	17.4	20.0	130
Do. stem	16.7	30.9	9.3	8.8	135
Do. web	18.0	33.2	16.3	17.2	145
Forged and annealed web	27.0	37.4	30.6	53.6	150
Forged stem	29.6	38.4	24.7	37.9	165
Oil quenched and tempered	27.6	42.0	18.4	12.1	185

The tests were made without the company's knowledge, and did not represent in any way special casts.

He then read the following analyses of exhibits which were passed round for inspection :—

Fracture No.	Carbon.	Silicon.	Manganese.	Sulphur.	Phosphorus	Nickel.	Chrome.
1. 4% nickel chrome used for aeroplane work	0.29	0.23	0.44	0.018	0.010	4.56	1·25
2. Dead soft nickel, for case hardening ...	0.12	0.22	0.46	0.020	0.010	2.12	
3. 2% nickel chrome ...	0.28	0.22	0.48	0.033	0.009	2.12	1 09
4. 2½% nickel; 1.15 chrome; for aeroplane work	03.1	0 22	0.44	0.022	0.011	2.54	1.15
5. H.F. 142	0.28	0.22	0.55	0,026	0 013	4.44	1.40
6. D.S.N.	0,16	0.22	0.40	0.023	0.011	2 14	—
7. L.F 142	0.31	0.23	0.49	0.020	0.009	4.44	1.55
8. H.C.	0.88	0.22	0.41	0.022	0.012	—	—
9.	0.66	0 24	0.42	0 027	0.013	—	—
10. H C.	0 94	0.24	0.37	0.023	0.012	—	—
11. C H.	0.34	0.23	0.16	0.026	0.013	—	—
12. H C.	0.68	0 19	0.44	0.022	0.010	—	—

The second alloy above-mentioned—the 2 per cent. nickel—was one of the finest case-hardening steels manufactured by the Héroult electric furnace; the first, third and fourth were nickel-chrome steels used for aeroplane work. No. 8 was a tempered piece of high-carbon steel, used for chisels and other tools.

In reply to a question by Mr. H. W. Aston in regard to the introduction of wood blocks in the roof of the furnace, the author said they were not exactly wood blocks, but pieces of wood 1mm. in thickness, 9 in. long and 4½ in. wide (the length and width of the brick), and were put against the brick in the silican joint. On firing they burnt out and allowed the bricks to cement together.

Lieut. Gordon wished to know the thickness of the brick lining of the electric furnace. It was only 9 in. thick, the same thickness as the roof.

The President asked whether the metal was poured direct into the mould or poured first into the crane ladle? The author replied that it was poured into the crane ladle first, and all steel was run or poured from the bottom of the ladle by means of a stopper.

In reply to Mr. L. C. Harvey, the cost per ton of steel depended on the class of steel being made, and varied for nickel-chrome, silicon steel, and other kinds. The ordinary carbon steel cost between £9 and £11 in the ladle. The electrode consumption was about 30 lbs. per ton of steel. The upkeep and maintenance were included in the £9 and £11.

Lieut. Hayes asked what raw materials were used in the process employed, and the author replied that they did not use raw materials. They made the steel from scrap—the ordinary shell turnings.

The President referred to the 8 per cent. loss mentioned by the author, and asked what was lost out of the metal?—They lost carbon, manganese, silicon, and all oxides that were in the scrap. It all went into the slag. It ran out on a 3-ton charge at about 8 per cent.

In reply to Mr. H. G. Barrett.—The furnace he had described was a 3-ton furnace, but as it got bigger larger charges were put in. At present they were putting 4 tons 5 cwt. in the 3-ton furnace. The average number of heats in the furnace before lining was 135 to 145. The cost of lining per sq. ft. had not been calculated. The cost per ton for lining was about 3s. 6d.

In reply to a further question, he said he had

no experience of making brass in the electric furnace, but electric furnaces were now being used in this country for making brass in large quantities, for melting brass swarf.

At present the cost of power at Brimsdown, about which Mr. E. J. DAVIS inquired, was about 0.6d. per unit. The more power used the lower was the cost per unit.

As to whether the steels were in varying quality, when using all scrap, everything was brought down to the same level in carbon, silicon, and manganese, and the additions made according to the quality and class of steel required. In making nickel steel, if one were working with nickel scrap, the nickel always varied, it could not be removed.

THE PRESIDENT said he thought the process of electric melting, as described by the author, was all right for scrap metal, but he must criticise the electric furnace for the making of fixed analysis steel. He did not think they must go away with the idea that they could make or produce a steel from the electric furnace to a fixed analysis for a fixed purpose. Nevertheless, they had been given a lot of information, which they hoped would be helpful to them as foundrymen, to enable them to make castings from scrap, and if they could do that they would have made some advancement.

MR. ASTON said he considered the electric furnace was the furnace whereby one could put in just what was required and create what was wanted, because by that process all the impurities were eliminated. It seemed to him the ideal process.

MR. BARRETT, in seconding a vote of thanks to the author, which Mr. Aston proposed, said he was surprised to find so many steels could be produced from the electric furnace. He was under the impression that it was more limited in its applications.

Advance in Pig-Iron Maximum Prices.

At the time of going to press it was expected that an Order would be issued from the Ministry of Munitions dealing with the new arrangements as to pig-iron prices. The Order, it appears, will not now be ready until this month.

Advance in Cleveland and Lincolnshire Pig-Iron.

In the meantime we understand that an Order will be published shortly authorising an advance of 2s. 6d. per ton on Cleveland foundry, forge and basic pig-iron, and an advance of 5s. per ton on Lincolnshire foundry, forge and basic pig-iron.

Maximum Prices for Tap, Mill and Flue Cinder and Scale.

It is also understood that an Order will shortly be issued fixing a maximum price of 30s. per ton f.o.t. producers' works for tap cinder, mill and flue cinder, and scale.

These advances are, of course, independent of any subsidy scheme, which is still under consideration.

MR. G. WILTON has disposed of his interests in the Chemical Engineering and Wilton Patent Furnace Company to a private limited liability company. Mr. Wilton, who had the sole active control of the former company for the last 15 years, will practice as an advising and consulting engineer at 109, Victoria Street, Westminster, London, S.W.1.

"F.T.J." Bookshelf.

The Founder's Manual. By DAVID W. PAYNE.—London: Crosby Lockwood & Son, 7, Stationers' Hall Court, Ludgate Hill. New York: D. von Nostrand Company.

The author, in his foundry experience, covering many years, has frequently spent hours at a time searching for special information. Believing, therefore, that a compilation of such matter with authoritative instruction for the solution of the many problems which continually present themselves in the foundry, all properly arranged for ready reference, would receive a favourable reception, he has produced the extremely useful manual under review for the use of foundrymen, foremen, students, and others. The material for the book has been drawn from various sources, principally the "Proceedings" of the American Foundrymen's Association, the publications of numerous experts, and the files of "The Foundry," "Castings," and "Iron Age." In the selection of the material for the book, proper consideration has been paid to the needs of beginners. About one-third of the volume is devoted to what is strictly mechanical and engineering information, rather than foundry data; but doubtless it will be appreciated by founders. The remainder summarises foundry practice, and gives a lot of useful information on matters not usually included in foundry text-books. The treatment of non-ferrous alloys, however, is very meagre; in fact, this side of founding receives very little attention at all. The pig-iron portions of the book deal essentially with American practice and irons. A good deal of information is contained in the portions dealing with the influence of constituents on properties of cast iron, but in this, as in other matters, the author has a tendency to be dogmatic on points which are still open questions between experts. To say, as the author does, that in Réaumur malleable cast iron the carbon is "completely eliminated" is rather misleading, if not quite inaccurate. Nevertheless, when due allowance has been made for the fact that the book is essentially an American compilation—the pig-iron directory, for example, dealing with American furnaces and irons, is not of great value to British founders—it will still be found to be of considerable utility to anyone engaged in the foundry trade.

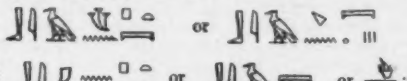
BOOTH-HALL ELECTRIC FURNACES. — The electric furnaces of 8- and 10-ton capacity built by the Booth-Hall Company, of 565, West Washington Boulevard, Chicago, are three-phase; those of 1½-ton capacity for the melting down of scrap are single-phase, except where the power conditions are such that a single-phase load is not acceptable, in which case the two-phase furnace is recommended. Their furnaces of 2½ to 6-ton capacity are two-phase.

INSTITUTE OF METALS.—The Hon. Sir Charles Parsons, K.C.B., F.R.S., Member of Council of the Institute, is to give the eighth Annual May Lecture before the Institute of Metals next spring. The lecturer will deal with the subject of the formation of diamonds. For over thirty years he has been experimenting upon the production of artificial diamonds. An account of his researches, which have an important bearing on many branches of applied science, cannot fail to be of the greatest interest. A ballot for the election of members of the Institute of Metals is due to take place on December 12. Forms of application for membership can be obtained from Mr. G. Shaw Scott, M.Sc., secretary and editor, 36, Victoria Street, Westminster, S.W.1. The present year has witnessed a remarkable growth in the Institute's membership—from 660 to over 860. It is expected, in view of the war-stimulated "metallurgical renaissance," as it has aptly been termed, that the 1,000 mark will be passed in the coming year, which also will be the year of the tenth anniversary of the Institute's foundation.

The Use of Meteoric Iron by Primitive Man.

(*Continued from page 597.*)

It is significant that nearly all the ancient folk of culture used in their appellation for iron such words which translate into "Metal, or something hard, from heaven." Thus the Egyptians used *ba-en-pet*, variously written as follows :—



the Assyrians and Babylonians AN.BAR. or *parzillu*, written thus . It is the same in the language of Sumeria and Chaldea—*barsa*, originally *barsal* and *barzel* respectively, and in the Hebrew ברזל all having the same meaning, and it does not require a stretch of imagination that by the name "Metal of Heaven" they meant meteoric iron.

The Greek name for iron, σίδηρος (*sideros*) has undoubtedly affinity with *sidus*—a star, and this also points to the meteoric origin of iron.

It has been suggested that the Egyptian name was comparatively modern and not given to iron till after it had been produced from the ore, simply to signify that such metal sometimes falls as it were from heaven. This argument is undoubtedly strengthened by the fact that the earliest larger piece of iron extant and found in the Great Pyramid is of terrestrial origin. It must also be admitted that the earliest name in the hieroglyphic for iron was *min*, . At the time when it was so named meteoric iron was no doubt found and used without the users knowing whence it came, and that its name was changed as soon as its origin was discovered into *ba-en-pet*, and as this change did not take place till the Ptolemaic age was nearly reached, we must admit that it took over 2,000 years to find this out; but there is nothing extraordinary in this, when we consider that out of about 300 iron meteorites known to us to-day only about ten have been seen to fall.

What is perhaps even more significant than the above is the inference we can draw from the following. In the heroic period of Homer there was no word for metal, only the verb μεταλλάω (metallao), the base which merged later into the noun μεταλλον (metallon). *Metallao* is derived from μετ = in quest of or in pursuit of, and αλλα = other things, so that the original meaning of μεταλλαω is "to search carefully or diligently after other things"; in time it meant also the spot where the search was made, and eventually the objects searched for; or in other words, the present Greek word *metallon* for metal has been derived from a root which in succession meant "diligently searching for other things" (that is, meteoric iron, not stones, as in the Stone Age), in course of time the spot where such other things were found (quarries or mines), and finally the metal itself. It does not appear logical to put any other aspect on the subject, for meteorites have to be carefully and diligently searched for, while the ore is generally found where indigenous without much difficulty, but the quarry or mine took its name at one time from the diligent search for the meteoric iron, which had to be made prior to the production of the metal from the ore.

At the time when the word *metallon* was first mentioned by Herodotus it signified "pit or quarry," and it did not stand for metal again until a later literature was reached; but this is only what might be expected, as iron must have been produced from the ore at least 400 years before Herodotus's time, and the word had by that time lost its original significance. Philologians have tried unsuccessfully to trace the origin of the word "metal" to the Indo-Germanic and to the Proto-Semitic races. Lexicographers do not appear to know the derivation, and should the foregoing conjecture be realised as a fact, the name "metal" could fittingly be traced to the most important of its class—Iron.

It is easy to imagine that when a man of the Neolithic Age, searching for suitably shaped stones from which to form his weapons or tools, picked up an iron meteorite, its abnormal weight attracted his keen interest. To him it was a stone which did not require chipping, but which could be altered in shape by hammering, and if the man or his associates had previous experience with copper, his fundamental metallurgical knowledge would be of distinct advantage to him. If he could work copper he might have known the use of fire, and if not, the mere rough shaping and then polishing the meteoric iron (which has a fine silver-like surface which does not easily rust) must have been a great success and the envy of his fellow-beings. The find and subsequent production from it, however crude it may have been, was such an advance upon his stone implements that his tribesmen all went to "search diligently for other things," and as meteorites, particularly the smaller ones, rarely fall alone, but in greater numbers, it was more than likely that others were found in the same locality. This may sound like a fairy tale, but it is suggested for what it may be worth.

Dr. G. Schweinfurth relates in a letter to W. Belck that in his opinion the ancient Egyptians must have known of meteoric iron, and that in a naked desert such objects are more easily found than on other lands, he himself having found what appeared to be a cannon ball about 30 kilometres east of Cairo in the Wady Dugla, which proved to be a siderite.

It is most extraordinary that although in oldest antiquity it was perfectly well understood that meteorites were extra-terrestrial bodies, and also equally well understood in the classical age of Greece and Rome, when meteorites were worshipped for that very reason, yet the learned men of only a little over a hundred years ago—at the end of the eighteenth and beginning of the nineteenth centuries—pooh-poohed the idea. The French Academy of Science decided by ballot that there was no such thing as meteorites from an outer cosmic space. Professor Chladni, who had the courage to pronounce meteorites as being of celestial origin, was all but insulted by his learned brethren. Chladni states that in the early part of the nineteenth century many meteorites were thrown away in his day because the Directors of Museums were ashamed to exhibit specimens reported to have fallen from the sky. The great fall on April 26, 1803, at L'Aigle, Normandy, at 1 p.m., witnessed by thousands of persons, finally settled the matter.

Concerning the structure of meteoric iron, this is too complex a subject to be discussed within the narrow limits of this Paper* but the following very sketchy account may be deemed sufficient for our purpose.

The widely varying reports and opinions expressed on the nature of meteoric iron are fully justified by the manifold varieties of this material. Only the meteorites known as Ataxites and Hexahedrites are homogeneous or nearly so, the rest lack homogeneity, and are of a more or less crystalline character, the crystalline formation varying with the percentage of nickel present, and this is graduated from the finest to the coarsest octahedral structure, the percentage of nickel decreasing gradually. The want of homogeneity in the crystalline structure is due to the fact that each crystal is, so to speak, composed of three different nickel-iron alloys. The plates parallel to the octahedral faces or planes are alternately poor in nickel (6 to 7 per cent.) and rich in nickel (25 to 38 per cent.) (named kamacite and taenite), while the body is filled up with a medium alloy about half-way between the two (named plessite). Thus, if a section is taken from one of these meteorites, polished and etched, the Widmanstätten figures become visible, owing to the acids dissolving the different alloys at a different rate (which, by the way, is the best and only reliable proof of the meteoric origin). The mere presence of nickel, which was at one time deemed sufficient proof of the meteoric origin, is not now considered determinative. Meteoric iron rich in nickel has a slightly brown tinge, whilst that poor in nickel is more silvery in colour.

In his *résumé* of "Analyses of Iron Meteorites Compiled and Classified," Mr. O. C. Farrington says:—"The most striking feature brought out by the analyses is the relation shown between chemical composition and structure. This seems to be definite and general. All the meteorites of hexahedral structure have a nearly uniform composition, while among the octahedral meteorites fineness of structure increases with the increase of nickel. . . . Practically all the members of the classes conform in composition to the average. . . . The apparent conclusion from the above results is, that the content of nickel influences the structure. It may also account for the change from a hexahedral to an octahedral structure, since the irons with hexahedral structure have the lowest percentage of nickel. . . . The percentage of nickel in iron meteorites as a whole, as shown by the reliable analyses, lies between 5 and 26 per cent. . . . Cobalt in iron meteorites rarely exceeds 1 per cent. No constant relation in amount appears to exist between it and nickel, although perhaps as a rule it is higher with higher nickel.

"Analyses of meteoric iron should always show iron, nickel, cobalt, copper, and phosphorus, and in most cases sulphur, carbon, and silicon.

"The specific gravity of meteoric iron is between 7.6 and 7.9. Since the specific gravity of pure iron is 7.85, it will be increased by that of nickel 8.8 according to the proportion of the latter. It will be decreased by accessory minerals, such as troilite (ferron sulphite, FeS), sp. gr. 4.7; schreibersite (phosphide of iron, Fe_3P), sp. gr. 6.5; graphite, sq. gr. 2.2; and oxidised ingredients or porosity."

* It is very lucidly and minutely dealt with by Dr. L. Fletcher, Director of the Natural History Museum, London, in "An Introduction to the Study of Meteorites."

Having now dealt with the subject as a whole, and in order to substantiate some of the former statements, the following points will yet have to be proved:—

(1) What proportion of the known meteoric iron is malleable?

(2) Was the form and size of individual masses of meteoric iron suitable to be wrought into weapons and implements, and could portions of larger masses be severed by primitive means for the use of man?

(3) Was meteoric iron as scarce as we might be led to believe, or were there more falls in antiquity than now?

(4) Geographical distribution of the known iron masses of meteoric origin.

(1) *What Proportion of the known Meteoric Iron is Malleable.*—By way of answer to this question the author submits a table which includes all meteoric iron, siderites and siderolites that are sufficiently well known and upon which data have been obtainable from the somewhat scattered literature on the subject. For this table, which extends to considerable length, we must refer our readers to the original Paper, but the author presents the following *résumé* of the data set forth in it.

The amount of meteoric iron known to us at the present day is about 253,472 kilogrammes (practically 250 tons). Of this total 239,326 kilogrammes is malleable iron and 1,358 kilogrammes non-malleable, and concerning the remaining 12,786 kilogrammes, there is not sufficient information available to determine whether it is malleable or not. If we look into the proportion of malleable to non-malleable, we find that 99.44 per cent. is malleable. If, therefore, we apportion the 12,786 kilogrammes which are uncertain in the same ratio, there should be 12,715 kilogrammes malleable and 71 kilogrammes non-malleable. This will bring the totals up to 252,043 kilogrammes of malleable and 1,429 kilogrammes of non-malleable iron. Even the small proportion which is given as non-malleable may possibly be found malleable under proper treatment.

This *résumé* cannot really be surprising to the metallurgist, for why should meteoric iron not be malleable? Speaking generally, all iron, with the exception of cast iron, is malleable, and even some varieties of cast iron show slight ductility. Pure iron, such as native or telluric, is highly ductile, and it is only the admixture of impurities in the cast iron, such as sulphur and phosphorus, etc., which make it brittle, as when they are eliminated by the Bessemer process the iron is rendered pure and therefore malleable. In other words, though all pure iron is malleable, certain impurities will impair such malleability, until they are present to a comparatively high degree, as in cast iron, when it becomes brittle. Nickel being always present in meteoric iron cannot impair its malleability, as nickel itself, or as an alloy with iron, is malleable. It is well known that the artificial alloy of iron and nickel (nickel-steel) combines the ductility of homogeneous iron (fluss-iron) with the advantages of hard steel, and is the best kind of modern iron. Wolf, who first introduced artificial nickel-steel, brought it on the market as "Meteor Steel." The addition of only 1 per cent. of nickel renders iron hard and tough, up to 3 per cent. improves the alloy (modern armour plates contain, by the way, 3¼ per cent. of nickel, and do not crack even when deeply penetrated by a projectile), and with more than 9 per cent. the nature of the alloy

gradually changes from that of nickel-iron into that of nickel. From the chemists' point of view, the principal difference between meteoric and manufactured iron is, the lack of chemically bound carbon and the presence of a comparatively high percentage of nickel in the former. So we see that primitive man had the advantage of a material which was not available to modern man till 1890.

2. *Was the Form and Size of Individual Masses of Meteoric Iron suitable to be Wrought into Weapons and Implements, and could Portions of Larger Masses be Severed by Primitive Means for the Use of Man.*—It is not intended to enter into the various learned theories expressed by experts concerning the reason for this or that formation of these celestial aliens—which have never been beheld by man in their original form in which they entered into the atmosphere of our planet—as it would not serve our present purpose. We will rather discuss them as we find them, after they have undergone certain changes while passing from an outer cosmic space through our atmosphere and have reached terra firma.

The general appearance of the majority of meteorites gives one the impression that they are fragmentary, and suggests that they are portions of larger masses. This is borne out by the fact that meteorites often fly asunder when nearing the earth, as fragments which fit together have been found ten miles apart. This shows that a single fall might spread over a considerable area, and it is obvious that many masses of known falls must thus be difficult to find or be lost, particularly such smaller pieces as might be wrought into useful objects.

We will now investigate, firstly, how large masses could be utilised. Meteoric iron was cut by the ancients in the same way as they cut pieces off the large masses of native copper found on the banks of Lake Superior. A block of such copper which was found in 1875 on the territory of the Minong Mining Company (Isle Royale, Lake Superior) 16 ft. 6 in. below the ground in ancient workings and which weighed 5,720 lbs., showed definitely the marks of primitive tools where portions have been severed. A piece which had been so detached in antiquity has been found in Ohio, hundreds of miles from the main mass. A similar mass of copper in the Minnesota Mine, near the Ontonagon River, also in ancient workings and 18 ft. below the surface, weighing 6 tons, had been nibbled all round by the Stone Age man.

It is, of course, not suggested that iron can be cut as readily as copper, but the following incident, showing how primitive man, with the simplest tools and patience, can cut up heavy masses of iron, happened in 1727 after Roggeween had lost one of his ships on one of the South Sea Islands. The natives collected all the iron from the wreck eagerly, lifted the anchors from the sea in the harbour of Tahiti, cut them up, and the King of Tahiti sent a piece of one of the anchors as a rare present to the King Opuni of Borabora.

Of money in the early days of antiquity there was, of course, none. The man who had the best weapons or tools was the Crœsus of the community. The expenditure of time on such implements was a matter of absolute indifference, as the weapons, etc., of all primitive people clearly show. If it took a man a month or more to saw off a piece of an iron meteorite with a flint saw, or bend a projecting portion back and forth with a heavy stone hammer till it broke off, and then work it into a weapon, it was of no consequence, as it must have taken him as long a time to polish an inferior stone implement in the neolithic age.

Some of the meteoric irons are moreover easily divided along the cleavage planes of their crystalline structures, such as is the case with Bridgewater, Waldron Ridge, Black Mountain, Carthage, El Ranchito, Holland's Store, Indian Valley Township, Jenny's Creek, Iredell, etc. They can be broken with a heavy stone hammer, and are none the less malleable at a low red heat, and when once wrought into form become compact masses, no longer friable. Some of the siderites, especially after weathering, become lamellar at the surface, so that flakes can be prised off with a hard wood wedge or other primitive tool, which would yield knives and scrapers, such as are found in use among the Eskimos. This flakiness is well demonstrated on the large mass of Coahuila (weighing 250 kilogrammes) in the Natural History Section of the British Museum.

It should also be mentioned here that siderolites are of two types, known as *Pallasites* and *Brahinites*. In the former the iron forms a skeleton, so to speak, that is of ramified structure, with many branches and branchlets spreading throughout the meteoric mass, the interstices being filled with a more or less crystalline friable mineral mass, olivine, as in the Pallas Iron, Vaca Muerta, Finmarken, etc. In the *Brahinites* the crystalline mass forms a continuous body, enclosing generally independent iron masses (not connected together) as is the case in the Estherville, Taney County, and Ilimaë irons. The smaller masses so easily detached from the latter form practically complete meteoric individuals, ranging from the size of a fist, a hen's egg, a walnut, to that of a pea. Their form is naturally very irregular, and they do not resemble the objects mentioned except as regards bulk. In either case, and especially in the latter, masses of iron suitable for the manufacture of implements can be separated with a minimum of exertion, as the crystalline mineral mass is brittle and therefore readily broken up, thus releasing the iron.

In the majority of falls of meteoric iron only a single mass has been discovered; in perhaps twelve instances two masses; and the falls of a greater number of masses are less frequent; they include the so-called showers of meteorites which yield the most fertile field for our present purpose.

Before, however, entering into the multiple falls or the showers, it will be interesting to extract from the table previously given the number and the average weight of meteoric masses of 5 kilogrammes and under, as such masses even up to 5 kilogrammes might be manipulated under favourable circumstances by a primitive Vulcan. We find that there are sixty such masses not exceeding 5 kilogrammes, with a total weight of 142.93 kilogrammes and averaging 2.382 kilogrammes. Among the multiple falls we have those shown in Table I.:—

In addition to the above there is the enormous shower of Cañon Diablo, which, besides the larger masses, yielded 131 smaller fragments from 6 lbs. 10 ozs. (3.006 kilogrammes) to 1-16 oz., or 1.79 gramme, and since the property has changed hands the new owner has collected thousands of fragments aggregating to more than a ton. The Estherville, which fell on May 10, 1879, included small masses found a few months after the fall, and some four miles from the spot where the seven large masses fell, over 5,000 nodules of iron ranging in size from

that of a pea to a pound in weight (H. J. Preston); likewise Ilimaë, besides two large masses, about 3,000 small ones have been found. The last two falls, Estherville and Ilimaë, are siderolites.

Apropos to the Toluca iron in the preceding table, it might be mentioned that a diligent search was conducted by Dr. Krantz in 1856, in the Valley of Toluca, when 69 individuals were found, weighing together 99 lbs. The largest weighed 1.725 kilogrammes and the smallest 58 grammes. These were all masses of a size which might have been

TABLE I.

Name.	Total number of masses.	Masses of 5 kilogrammes and under.	Total weight of masses of 5kilogrammes and under
			Kilogrammes
Cachiyuyal	2	1	2.55
Bischtübe	3	1	0.205
Jewell Hill	3	2	4.433
Angela	3	3	9.886
Oscuro Mountain	3	3	3.369
Powder Mill Creek	3	2	4.309
Jenny's Creek	3	2	1.5
Smithville	4	1	3.175
Youndegin	5	1	2.7
,, ...	—	Broken fragments, say 10	7.711
Staunton	6	2	3.04
Tombigbee River	6	3	7.585
Trenton	6	1	3.628
San Cristobal..	7	7	4
Santa Rosa	8	2	1.242
Glorieta Mountain	9	4	7.88
Brenham Township ..	30	5	9.976
Toluca	?	69	44.905
Llano del Inca	?	At least 100	12.25
..			
		219	134.344

219 masses with an average weight of 0.6134 kilogramme.

handled and wrought into objects by a primitive people, especially as their form was variable, conforming to some degree to a variety of objects. The oval form was prevalent, *i.e.*, in fifty-six cases, two were nearly spherical, five cylindrical, and six flat.

We thus see from the foregoing that the cosmic sources of iron available (if we judge from the present-day knowledge of similar masses) to primitive man was:—(*a*) Projecting portions detached by primitive tools, or pieces flaked off from larger masses; (*b*) siderites of a friable crystalline structure easily broken up; (*c*) siderolites in which the ramified iron or the nodules have been separated from the brittle mineral matter (olivine) by hammering; (*d*) complete meteoric individuals of 5 kilogrammes and under in weight.

It is impossible to form any idea as to the quantity likely to be obtained under (*a*) and (*b*); (*c*) might be taken to yield roughly two-thirds of the available siderolites, which would be about 10 tons.

	Kilogrammes.
For (*c*) say	10,000.00
Whilst (*d*) represents 60 masses weighing together..	142.93
And (from multiple falls) 219 masses weighing together	134.344
And (from Cañon Diablo from multiple falls, say 2,000)	1,000.00
Without (*a*) and (*b*)	11,277.274

The material available to primitive man was thus not inconsiderable, especially if we conclude, from what will be said later, that meteoric falls were probably more frequent, and similar iron masses to those which now fill the cabinets of our museums would in all probability not be wasted by an ancient people. In fact, we have seen that portions of the Benham, Eagle Station, and Descubridora irons were used by a neolithic people of America.

(3) *Was Meteoric Iron as Scarce as we might be led to believe, or were there more Falls in Antiquity than now.*—A study of ancient literature and documents reveals the fact that the falls of meteorites and so-called "star showers" have been very numerous; at any rate, ancient writers convey in unmistakable language the idea that the falls of meteorites were very well known—in fact, so much so that one might conclude from these references that they fell more frequently, without overstepping the bounds of veracity.

It is, unfortunately, impossible to deal here with meteoric iron separately, the information generally being too scanty, so when falling stars or meteorites are mentioned, it refers indiscriminately to stones or iron. If the proportion were the same in antiquity as now it would be about five of iron to six of stone. In the following some of the more important references are given.

To begin with, according to Holy Writ meteoric falls could not have been infrequent in Phœnicia and Syria. The destruction of Sodom and Gomorrah in 1984 B.C. was probably wrought by such agency. In Joshua x. 11 we read that great stones fell from heaven, in the battle of Gibeon, on the army of the Canaanites. A siderolite of the Brahinite class could fitly be named a stone by the ordinary observer, and we know that such meteorites frequently exploded in the air, spreading the iron nodules shrapnel-like over a large area (like the Estherville fall), and such a phenomenon on a larger scale would deal death, as described in the Book of Books. The Psalmist (in Psalm xviii. 13) says: "The Lord also thundered in the heavens, and the Highest gave His voice; hailstones and *coals of fire*." The latter expression, says Edw. King, in consistency with common sense, cannot but allude to such phenomena (meteorites); and especially as in the Septuagint a Greek word is used which decidedly means *real hard substance* made red-hot, and not mere appearance of fire.

We further read in the Acts of the Apostles, chap. xix. 35, concerning the image of Diana: "Ye men of Ephesus, what man is there that knowest not how that the city of the Ephesians is a worshipper of the great goddess Diana, and of the *image* which fell down from Jupiter?" or rather, as the original Greek has it, "of *that* which fell down from Jupiter."

A legend is found in the Talmud concerning the plague of hail in Egypt—that the hailstones were as large as the head of an infant, and that as they struck the ground they burst into flame. (This appears the more likely as there is no sharp distinction drawn between stones and hailstones in the Bible, and a fall of hail is probably an unknown occurrence in Egyptian history.)

Pliny, our first mineralogist, informs us ("Natural History," ii. 58) that the deities sent stone showers upon earth, and mentions as one example a shower which occurred during the third consulship of Marius in the time of the Cimbrian War. He also speaks of ("Natural History," ii. 58) a sponge-like iron mass which fell about 56 B.C., the year Crassus was killed by the Parthians, in Lucania (the present Apulia, Abruzzo, and Calabria). This description tallies very closely with the structure of a Pallasite. In his "Natural History" (xxxvii. 61) we read of

another stone shower with finger-like masses, on Ida, Crete. It is significant that the early inhabitants of the mountain of Ida in Crete were said to be the sons of Vulcan, and the first to produce iron; or did they find it? Another meteorite named by Pliny ("Natural History," xxxvii. 9), Astroides, was used by Zoroaster in his magic arts.

Pliny goes rather fully into the subject ("Natural History," xxxvii. 51 and 52), describing the colour of different kinds of meteorites and their imaginary supernatural power, and winds up by saying they were diligently sought after by Parthian magicians, or magi, as they are found on the spots struck by lightning, and that such stones were found on islands of the Red Sea, and, according to travellers, in Southern Persia, and indeed all over the earth. (The belief that such meteorites were the creation of a stroke of lightning was widely accepted by primitive people, and not unnaturally so, owing to the similarity of the phenomena of the fall of a meteorite and a stroke of lightning.)

Meteorites were not only objects of worship and adoration, but were also used as battle-axes. They are frequently found (particularly in the north) either free in the ground or enclosed in ancient burial-places. If Pliny's larger work on metals had not unfortunately been lost, what a source of further information it might have been!

According to Strabo, apparently another meteorite was worshipped by the Arab tribes as an image of the sun in the city of Emesa (the present Hems in Asiatic Turkey), which was a place of rendezvous for this purpose at a very early date.

According to Greek mythology, Cronos, the brother and husband of Rhea (Cybele), being afraid of one of his sons dethroning him, swallowed all his children immediately after birth. When, however, the infant Zeus was born, his mother concealed him, and handed a meteorite—sent from heaven for the purpose—wrapped in swaddling clothes to Cronos, who devoured it. The name Baetylus was primarily given to this stone swallowed in mistake for Zeus, but it seems to have been subsequently applied to all meteorites. Hesychius suggests that the Hebrew name "Beth-el" for the stone of Jacob is the origin of Baetylus.

Livy in his first book mentions a shower of stones that fell about 650 B.C. on the Alban Mount, near Rome, and carefully distinguishes this from hailstones. He mentions several instances of a rain of stones.

Cicero, in the grand closing passage of his oration against Verres, calls upon Ceres, whose image he says was not made by hands, but was believed to have fallen from the skies.

Betyl coins were struck from about 400 B.C. to A.D. 300 in honour of the deities worshipped in the form of meteorites by Emperors and autonomous cities as under Philip II., Alexander III., Augustus, Caligula, Vespasian, Trajan, Marcus Aurelius, Septimus Severus, Heliogabalus, Tacitus, etc., and in the countries of Macedonia, Cyprus, Mallos, Perge, Sidon, Tripolas, Tyrus, and many others. At least sixty varieties of such coins are known, and represent the meteorite generally as a conical stone or obelisk, often in a temple.

With reference to the stone in the Caaba, the most sacred jewel of Islam, called "The right hand of God on earth," legend has it that Mohammed built the stone in the east corner with his own hands. It is not certain whether this undoubted meteorite is the Betel Stone,* Dusares or Alagabal, though it is probable that whichever it is it was formerly worshipped at the temple sacred to the Moon which used to stand in Mecca. In Sale's "Introduction to the Koran" it is stated that the stone is supposed to have fallen before the Deluge.

A Chinese record dating back 644 B.C. mentions that from the commencement of the earliest history meteorites have fallen, and Biot has traced in Ma-tuan-lin the record of sixteen falls prior to 333 of our era.

Avicenna (Abu-Ali-Hussein-Ben-Abdallah), 980-1036, mentions several meteoric falls in Egypt, Persia, &c., drawing attention to the terrible noise accompanying the falls and the extraordinary hardness of the meteorites.

The people of Finland, who can boast of a very early civilisation, have in the "Kalevala" the early heroic songs, which deal largely with the glory of metal weapons and the art of the smith who wrought them, and here we are told that Ukko created three virgins or aerial fairies, and that the milk they shed from their ample breasts upon the earth turned to iron, which lieth hidden throughout the country till the skilled smith Ilmarinen finds and conveys it to his smithy. This is an unmistakable hint at the meteoric origin of the first iron used.

In the early history of the Maggares or Wogules, expressed likewise in religion and poetical saga and song, in which the sword and the axe are revered with divine honours, not a word is mentioned alluding to the mineral wealth of the Ural Mountains, from which the metal must have been derived, unless it was either of meteoric origin or imported. This could hardly be overlooked accidentally, as the origin of tools and implements, the subject of fishing and hunting, the formation of homesteads, villages, and towns, and religious ceremonies, &c., are dealt with.

Falls of meteorites during the Middle Ages are too numerous to be mentioned here. Chladni tabulated them in 1803, and gave additional ones in 1812. These records are mostly embellished with fantastic and superstitious notions, but this serves to convince us that meteoric falls were not only well known, but also numerous. In Chladni's table and subsequent examples, omitting the early records already mentioned, forty falls are recorded, of which nine were so-called star or stone showers, and quite a few falls consisted of more than one mass and up to five. Some are specified as stones, some as iron, but the information is too vague in some cases to determine the proportion of siderites and aerolites, but there are at least six of the former.

P. A. Kesselmayer in "Uber den Ursprung der Meteorsteine," in 1860, enumerates 647 falls between 1984 B.C. and A.D. 1860, including the falls of fire, stones, iron, stars, earth hatchets, shields, chalk, meteorites (heavenly dogs), fiery anvils, stones like arrows, small axes, spears, iron clubs, stars which changed into stones, sulphur, rocks, fire-balls, iron slag, or clinkers. Of these only 304 appear to claim reliance. The complete list, including those of mythological mention, numbers 681.

Many ancient descriptions of meteoric falls give

* The stone which Jacob set up on Mount Libanus during his flight to Mesopotamia, after having used it for a pillow during the night, and after anointing it with oil according to an old custom, at a place formerly called Luz, which he changed into Beth-el (The House of the Lord). Genesis xxviii. 18 and 19.

accurate accounts of such phenomena, which coincide exactly with the bright light, the noise of thunder and explosion, and the descent of the meteorite itself; but as these ancient accounts are often so much interwoven with fabulous stories, they were treated by some of the translators with ridicule, and as they could not conceive the truth of such accounts, they have altered passages dealing with this subject after their own ideas.

We have seen that 246½ tons (or 250,493 kilogrammes) of meteoric iron are known to science, of which about 2½ tons (2,624 kilogrammes) may be non-malleable, and therefore of no use as far as our investigation is concerned. This leaves about 244 tons (or 247,869 kilogrammes) available for man. It is, of course, impossible to say during what period these masses have fallen, but they were not searched for in more modern times till about a hundred years ago, so that there was an accumulation to draw upon. We have already seen under the previous heading that all have not been found, so that the 246½ tons is the very minimum.

Professor Berwerth, of Vienna, has calculated that the number of meteorites actually falling upon the earth at the present time each year is about 900, or two or three fall somewhere every twenty-four hours. As three-quarters of the earth's surface is covered with water, there should be 225 falls for the remaining quarter, but as a large part of the land is unpopulated, the 225 might be halved for the falls on cultivated land.

Between 1800 and 1910 the falls of meteorites recorded were 331. In the year 1868, eleven falls were recorded; in three years, seven falls each; in ninety-five years from one to six masses per year; and in eleven years no record of any fall. The fact that the northern hemisphere has had the greater number of falls is undoubtedly to be accounted for by the fact that the vast majority of the land is disposed over that hemisphere.

Taking the known falls and finds together, they are apportioned over the eastern and western hemispheres as follows:—

Eastern—Iron,	79;	stone, 299;	together, 378
Western— „	182;	„ 74;	„ 256
	Iron, 261;	stone, 373;	together, 634

This diversity cannot be explained, but there can be no doubt that it conforms to a law which will some day be understood by the human mind.

It is an extraordinary fact that of the known iron meteorites only about ten have been seen to fall, whilst of aerolites, or stony meteorites, over fifty have been seen to fall. This seems to indicate that during earlier centuries iron meteorites were more prevalent than at the present time. It is certainly a fact that fewer iron meteorites are found in the Old World than in the New, which is an argument in favour of the use of meteoric iron by primitive people. The Old World having as a whole the older civilisation, the meteoric iron was used up by the ancients, while in the New World it has accumulated and is now being found.

"It is not to be wondered," says Mr. Arthur Harvey, "that the meteorites are more frequently found in America, for those which have fallen in the Eastern Hemisphere have been turned to some uses, often fantastic, centuries ago. They have been forged into weapons with magical attributes, set up as idols, pounded for medicine, and worn as amulets."

If we compare the mention of meteorites in ancient and modern literature, we are almost forced to believe that meteorites were more plentiful in olden times, as there was sufficient material to supply the small wants of a comparatively thin population; for we must bear in mind that when primitive man used iron first, he used it most probably in the same way in which he used copper 8000 B.C.—that is, for pins and needles and such other objects in which, for instance, small flakes of iron could be used inserted in bone handles, like the knives of Baffin's Bay, and similar to the sickles of ancient Egypt (though none with iron inserted have been found). Where larger masses were used they were probably employed in the same way and form, as stone axes and adzes with the haft tied on. Better chisels and knives were probably not made till experience had been gained in the making of pins and needles, and after the use of the smith's fire was understood.

In conclusion we may say that primitive man before 1200 B.C. used iron more or less sparingly, which iron was obtained from—(*a*) Iron meteorites. (*b*) Chance productions by a camp fire, a flash of lightning, a forest fire, through volcanic agency, or, as Edw. B. Taylor suggests, from magnetic iron ore. (*c*) Telluric or native iron. The large masses of supposed telluric iron are not here taken into account, because they are confined to one locality, Greenland, and no one dare say with absolute certainty that they are of meteoric origin, so in fairness to all they are here ignored.

STANDARDISATION OF CRUCIBLE SIZES IN AMERICA.—The Committee on Standardisation of Crucible Sizes appointed by the American Institute of Metals has submitted to the Institute a list of standard sizes of graphite crucibles to which the crucible makers have agreed. The list comprises 25 sizes, varying in height from 8¼ to 24½ in., and in bottom width from 5 to 14 in.

PERMANENT MEMORIAL TO WOMEN'S WORK ON ENGINEERING MUNITIONS.—It is part of the scope of the Women's Section of the National War Museum that it should contain a permanent collection of engineering exhibits, illustrating the proficiency attained by women in work of an engineering nature in connection with the manufacture of munitions of war. The range of women's work on munitions and on other engineering work necessary to the war is so vast that a Special Committee has been formed to undertake the work of collecting suitable specimens, and firms are invited to assist this committee by submitting particulars of such examples as they would be willing to present to the National War Museum. The collection is only intended to illustrate the nature of work which women have undertaken since, and in consequence of, the war; and it will include details of aero-engines, aeroplanes, steam and other engines, motor vehicles, machine tools, guns, small arms, projectiles, gauges, cutters and small tools, gun-sights, and other articles coming within the limitation mentioned. The name and address of the firm giving the specimens may be recorded in a manner approved by the Committee, either on the specimen or on the case containing them. It is hoped that firms employing women on engineering work in connection with the making of war material will be willing to contribute specimens which will constitute a permanent memorial and record of the work women have done in the war. Communications should be addressed to the Hon. Secretary of the Women's Work Sub-Committee, National War Museum, 9, Queen Anne's Gate, London, S.W.1. It is not desired that samples be sent in the first instance.

Zirconia as a Refractory Material.

Before a recent meeting of the Refractories Section of the Ceramic Society a paper on "The Use of Zirconia as a Refractory Material" was read by MR. J. A. AUDLEY, B.Sc. The following are excerpts from the paper :—

Like a number of other naturally occurring substances, zirconia is a simple compound of oxygen with another element, in this case the metal zirconium. In recent years an abundant source of supply has been found in the mineral baddeleyite, consisting of from about 80 to 94 per cent., and even up to 98 per cent., of zirconia, associated with some silica and ferric oxide, a little alumina and titanic acid (or titanium dioxide), and smaller amounts of magnesia, alkalies, and other substances. The average amount of zirconia in baddeleyite may be taken as about 84 per cent.

Zirconia can be melted and volatilised in an electric furnace (360 amperes, 70 volts). Its resistance to both acid and basic slags is also very high. Its conductivity for heat is remarkably low, and its coefficient of thermal expansion is also very low, the linear coefficient being 0.00000084, close to that of quartz glass; it can accordingly be plunged while red-hot into water without cracking or breaking. All these properties are possessed by native zirconia containing 80—84 per cent. (or more) ZrO_2. It also resists fused cyanides and alkalies, being seriously attacked only by melting bisulphates and fluorides. Besides being exceptionally stable towards chemical reagents, it is very voluminous, and yet very hard, properties which make it available for important applications. Its low conductivity for electricity (except when strongly heated) make it well-adapted for insulating purposes, as in electrical heating apparatus.

Composition.—A typical analysis of baddeleyite gave the composition: 84.1 ZrO_2, 7.74 SiO_2, 3.1 Fe_2O_3, 1.21 TiO_2, 0.66 Al_2O_3, 2.72 loss on ignition (making a total of 99.53). Other analyses gave from 82 to 94.12 per cent. ZrO_2, with impurities in varying amounts. One specimen gave as low as 74.48 per cent. zirconia, but this appears to have been exceptional. Some specimens, on the other hand, gave as much as 96 to 98 per cent. ZrO_2. Most of the raw material (as previously intimated) has about 84 per cent. ZrO_2.

Technical Applications.—For the best results it is necessary to burn crude zirconia to a much higher temperature than that to which it is to be exposed; otherwise it cracks, being a bad conductor of heat. The composition in this case seems to indicate a rather low-grade material. Crude zirconia can be greatly improved by the removal of iron oxide, about half of which can be eliminated by dilute acid (sulphuric or hydrochloric). Another peculiarity, to which Dr. Rosenhain called attention, is that zirconia is very apt to carburise at high temperatures, and the zirconium carbide thus formed has very different properties from those of the oxide (zirconia), though the carbide is still refractory and hard. Zirconia, however, will not carburise in an ordinary furnace, where there is a sufficiently oxidising atmosphere.

In Germany patents have been taken out for the use of zirconia in a variety of ways. As a refractory it was applied to cutting muffles, retorts, and tubes, by Pyfahl in 1904 and in 1906 by the Heræus Company for crucibles in which quartz was to be fused to prepare quartz glass. Zirconia is also used in the filaments of the Nernst, Sanders, and Zernig electric lamps. As a lining for electric furnaces of the arc type, its high melting point, low thermal conductivity and low coefficient of expansion make zirconia particularly suitable, the natural product being quite good enough for this purpose.

The advent of zirconia as an article of commerce at comparatively reasonable prices enables it to be used for the manufacture of refractory bricks, the rather high initial cost of a zirconia lining, as compared with, say, magnesite bricks, being more than counterbalanced by its combination of high melting point, high resistance to corrosive slags (also to metals like steel, copper, and bronze, and metallic oxides), low thermal conductivity, and low coefficient of expansion. It has been placed on record that a zirconia-lined hearth of an open-hearth furnace in a steel works at Remscheid, after four months' continuous working at high temperature, was still in good condition and capable of serving at least four months longer before renewal would be necessary. Calculations based on the same tests showed in actual maintenance costs a saving of over 50 per cent. in favour of zirconia lining as compared with the refractory lining ordinarily used. In the calculations no allowance was made for increased production and higher efficiency.

Another interesting application of zirconia is in the manufacture of ferro-zirconium (containing up to 35 per cent. zirconium) by the aid of powdered aluminium (Goldschmidt's process), which has been successfully employed in Germany for the production of zirconium steel for armour plates, armour-piercing projectiles, bullet-proof steel, etc. The zirconium steels are particularly hard, and it is affirmed that 1-in. armour-plate of zirconium steel is equal to 3-in. armour-plate of the best German steel.

A mixture of about equal parts of zirconia and carborundum, the latter being coarser-grained, is said to be highly refractory, without showing the usual tendency of zirconia to crack and lose coherence. (See U.S. Patent 1159264, 1915, and English Patent 4080, 1915.) A refractory mixture for zinc muffles, consisting of 1 to 10 per cent. zirconia, 33.3 per cent. clay, and burnt fireclay, is specified in German Patent 287122 (1913). In German Patent 284395 (1914) Knöfler recommends zirconia, with or without titanium dioxide, for making porous refractory masses for flameless surface combustion. Zirconium carbide is hard enough to scratch quartz, and it has been proposed to use it for cutting glass, and as an abrasive. A mixture of 90 parts of the carbide with ten parts of ruthenium has been suggested for filaments of incandescent lamps, the carbide being a good conductor of electricity.

Quite recently O. Ruff and G. Lauschke investigated the refractoriness and other properties of zirconia, alone and mixed with certain other oxides. Summarising the results they obtained it was found that beryllium oxide, alumina, thoria, and yttria were suitable as additions to zirconia, owing to the advantageous circumstances of their melting temperature and their small volatilisation between 2,000 deg. and 2,400 deg. Beryllium oxide and alumina lowered the melting point of zirconia

somewhat, but in no case below 2,400 deg. Thoria and yttria were easily reduced to carbides, so that the melting temperature of thoria could not be ascertained, and that of yttria only after considerable formation of carbide. But in mixture with zirconia these two oxides are protected, so that the melting point of the zirconia is scarcely lowered. Magnesia seems less suitable. When heated alone it volatilised so quickly that it could not be melted at all in the vacuum furnace. Even when mixed with zirconia there was still considerable volatilisation. Silica melts at 1,850 deg., and volatilises even when mixed with zirconia.

Change of Shape.—In the firing, the smaller crucibles kept their shape, with a few exceptions, burned at 2,200 deg. and 2,400 deg. The larger crucibles, inside which the smaller ones were placed for burning, retained their shape substantially, except when the heating was one-sided or otherwise irregular. These larger crucibles had layers of carbide formed on their walls, and could not be used more than three times. Crucibles made from raw zirconia changed their shape below 2,000 deg., owing to volatilisation of the less refractory ingredients (chiefly silica).

Structure.—At temperatures of 2,200 deg. to 2,400 deg. the crucibles acquired a more or less crystalline structure, resulting from sublimation of zirconia. The surfaces of the larger crucibles were much more altered, owing to formation of zirconium carbide crystals. Crucibles made from raw zirconia were crystalline and blistered below 2,000 deg.

Compactness (or Density).—Unburned crucibles, both moist and dry, were about as compact as objects of good unburned clay, and addition of 1 per cent. of starch (either dry or as paste) increased their compactness. Crucibles burned at 1,500 deg. were as compact as a well-burned clay body, and above 2,000 deg. still more so. All were harder than glass. Crucibles burned at 1,500 deg. had a soft ring, those burned at higher temperatures had a hard ring.

Contraction.—In the preheating (at 1,500 deg.) the crucibles began to sinter and to contract at about 1,300 deg. The raw zirconia contracted somewhat more than the pure oxide. Addition of silica had no influence worth mentioning, owing to its early volatilisation. Beryllium oxide and alumina increased the contraction, especially when 6 per cent. was added. Magnesia, thoria, and yttria did not perceptibly affect the contraction, nor did starch, whether dry or as paste.

Loss of weight of the small crucibles was caused by formation of lower oxides and carbides, and by volatilisation of zirconia and the added oxides. Notable loss of weight was sustained by crucibles containing beryllium oxide and alumina, and those made from raw zirconia. In some cases gain of weight occurred, and is ascribed to sublimation of zirconia from the larger crucibles to the smaller ones inside them.

Porosity.—Crucibles of pure zirconia increased in density with the temperature at which they were burned. Silica under reduced pressure mostly volatilised below 2,000 deg. Beryllium oxide added in small quantities reduced the porosity up to about 2,000 deg.; in larger quantities and at higher temperatures it volatilised, and so increased the porosity. Magnesia behaved like beryllium oxide. Alumina increased density considerably up to about 2,000 deg.; at higher temperature and lower pressure it volatilised, making the material porous. Thus alumina is a suitable addition to zirconia up to 2,000 deg., about 1 per cent. being best. Addition of thoria greatly reduced porosity above 2,000 deg. Yttria acted best at 2,400 deg. (in reducing porosity).

The porosity of crucibles made from zirconia previously calcined at a comparatively high temperature, whether burned at 1,500 deg. or 2,200 deg., was found to be much greater than that of crucibles made from zirconia calcined at a lower temperature. Addition of starch (dry or paste) increased the porosity considerably. Thus, in order to obtain dense objects, oxides must be used which are preheated at a comparatively low temperature, and (according to the temperature which it is intended to use) a small quantity of alumina, or thoria, or yttria, should be added.

Changes of weight of the crucibles in the electric furnace are traceable to three different causes:—(1)—Reduction of zirconia, owing to reducing atmosphere; (2)—volatilisation of the added oxides; (3)—sublimation of zirconia. Reduction was slighter with crucibles burned at 2,000 deg. than with those burned at higher temperatures. Additions of alumina, yttria, and 6 per cent. thoria increased the extent of the reduction in burning at 2,400 deg.; but in general no great difference between the effect of individual oxides among one another and in comparison with pure zirconia was ascertained.

Conclusions.—By means of suitable oxide additions and correct choice of temperature, compact (or dense) objects with zirconia as basis, suitable for employment in exhausted carbon-resistance furnaces with reducing atmosphere, can be burned in such furnaces above 2,000 deg. For burning at 2,000 deg., about 1 per cent. alumina, at 2,200 deg. about 1 per cent. thoria, at 2,400 deg. about 1 to 3 per cent. yttria is the suitable addition. Larger additions are useless, and increase the porosity. Used in small quantities, beryllium oxide and magnesia reduce the porosity likewise, but not in the same degree. Silica acts unfavourably as addition.

GOVERNMENT ENCOURAGEMENT OF JAPANESE IRON INDUSTRY.—The British Embassy at Tokio reports that a Law, having for its object the encouragement of the iron industry in Japan, was passed at a recent special Session of the Diet, and was to come into force at the beginning of September. Its main provisions are: (1) That iron and steel works with an output of not less than 35,000 metric tons per annum will have the right to expropriate property on which it is necessary to locate works; and (2) that works turning out not less than 5,250 metric tons per annum will be exempt for eleven years from business and income taxes, and from all forms of prefectural, local and municipal taxation, as well as being allowed to import free of duty the machinery, etc., required for the works. With great industrial activity existing in the country, and the shipbuilding boom at its height, the passing of this new Law has resulted in the launching of a number of new undertakings. Supplementary regulations issued provide that an ironworks which is entitled to expropriate or utilise land in accordance with the Law must be a business connected with the production of pig-iron, steel, rolled steel (including rails and fishplates), materials for making forged or cast-steel manufactures, or such by-products as are indicated by the Minister of Agriculture and Commerce. The same regulation applies with regard to an ironworks which is entitled to exemption from business and income tax.

Melting Furnaces.*

By T. W. Aitken.

There are various forms of furnaces in general use in melting metals or alloys for founding, each form or type having its particular advantage over another for its specified work. The most common forms of furnaces are the cupola, the crucible furnace, the reverberatory or air furnace, and the electric furnace.

The Cupola.

The construction of the cupola appears simple, and that may lead some men to think that its operation also is simple. But when investigating the several points in connection with its structure, we find that its several dimensions must be related one with another if economy and efficiency are to be obtained. Taking first its diameter, there we have its definite melting capacity if all other parts are correctly proportioned. Its height, taken from the hearth to the charging hole, should be at least from four to five times its diameter, otherwise a great quantity of heat is lost which might be used in warming up subsequent charges of metal and fuel, and also there will be an insufficient density at the melting zone to maintain the required combustible mixture of gases at this particular part. The tuyere area must also be proportionate to the diameter, or rather the sectional area, this proportion, to give the best results, being tuyeres area $\frac{1}{5}$ the sectional area.

With such a tuyere area, the pressure of blast can be at its lowest and the furnace most efficient, it will also be less liable to bridge over or scaffold; further, the molten metal will suffer the minimum of oxidation. The question of pressure of blast is a very complex one, and no definite figures can be given which will hold good for all cupolas, for a hard coke will withstand and also require a greater pressure of blast than a soft coke, while also the shape of the tuyeres is a determining factor as to the pressure required. For instance, if the shape of the tuyeres is such that the blast is throttled, a greater pressure will be required than if the blast meets with no resistance whilst entering the furnace.

When considering blast pressure and volume we must first consider in what manner the blast affects the working of the furnace. It must not be accepted that the oxygen of the air simply consumes the fuel, but that the oxygen forms with the carbon of the fuel a proper combustible mixture, and to obtain such a mixture the carbon and oxygen must be gases; also to get the maximum heat from this mixture it must be in a definite proportion, this proportion being carbon-dioxide (one part carbon to two parts oxygen). Therefore to obtain this definite proportion the proper amount of oxygen must be supplied. If too much air is forced into the furnace, then we are likely to get oxidation of the metal, with the result that the silicon and other ingredients will be abstracted from the mixture and to a certain extent the cast-iron will be converted into a mixture that somewhat resembles steel.

One hundred pounds of good foundry coke needs about 15,000 cubic feet of air to give it the required quantity of oxygen to produce complete combustion, i.e., to form carbon-dioxide. This same amount of coke, if put on as one charge, should be consumed in about seven minutes, and should melt about 9½ cwt. of grey cast-iron. If too little oxygen is supplied into the furnace, the result may be a gas which has a very low calorific value, *i.e.*, carbon monoxide (one part carbon and one part oxygen), or it may result in a smaller quantity of the carbon of the fuel being consumed in a given time, with the result that the furnace will melt slowly and the metal be dull. It is often overlooked that unless the fuel is at a bright red or incandescent heat, it cannot consume oxygen very rapidly, and if a great pressure of blast is forced into the furnace before the fuel has reached this temperature, only a small percentage supports combustion, the remainder having the effect of cooling or blowing cold. This is a common fault with many furnacemen when first putting on the blast, and I should certainly advise all furnacemen to never be in any hurry to put on full pressure of blast, rather have the wind escaping from the peep-holes or the valve for a time, if the speed of the blower or fan cannot be reduced.

We may now consider the course of the blast when it enters the furnace. This is always the same, the course where there is the least resistance, and it will be found, by taking close observation of the furnace whilst working, that after the pressure has been exerted, which forces the blast to the centre of the furnace, the blast and also the unburnt gases creep up the sides of the furnace, and unless the furnace is kept well filled all this heat is lost.

The size of the coke is a very important matter which is often overlooked by furnacemen. A piece of coke about 14 lbs. in weight will have a certain surface area, and it is only the surface of the coke that is consumed, being the only part that can be supplied with air or oxygen to support combustion; but if this piece is broken up into about six or eight pieces as large as a man's double fist, the surface area must consequently be increased, therefore a more rapid consumption must take place. If broken too small, however, the several pieces may be forced together by the pressure of the charges above same, and so resemble one large dense mass, with the result that the surface area will be greatly reduced.

The Crucible Furnace.

This form of furnace has been subjected to more improvements than any other kind of melting furnace, yet with all the modern portable furnaces on the market, hundreds of old-style pit fires are still in every-day use which are more costly as regards fuel consumption and are a great deal slower in operation. Possibly the only reason that can be given for their continued use is custom.

The modern crucible furnace is either arranged so that the molten metal is poured into a ladle by tilting the furnace or so that the mould may be cast direct from the furnace by means of a crane lifting the furnace bodily. The chief features in connection with such furnaces are rapid melting, low fuel consumption, and a much longer life of crucibles, owing to the crucibles not being exposed to the cold air of the shop whilst they are red hot. Several kinds of fuel have been tried and are still in use in connection with these portable furnaces, such as gas, oil and coke; but from my own experience, and I have used all three, there is nothing yet that can equal coke, for that the fuel entirely

* Read before the London Branch of the British Foundrymen's Association, October 12, 1917, Mr. J. Stone in the chair.

encircles the crucible from the bottom to the top and allows combustion to take place in all parts of the furnace at the same time, and not at one confined area, as is the case with gas and oil fuel. The coke also forms a protection for the crucible against the forced draught, and is a conductor of heat when one section of the fire has a greater heat than another. Unless the furnace, however, is particularly constructed, the use of coke fuel creates a great difficulty in the clinker forming around the bottom of the furnace and likewise the crucible, necessitating repeated stoppages to clear away, and in the event of the forced draught or blast being supplied from the bottom of the furnace, as is the case in the majority of these furnaces, then the quantity of blast is greatly reduced.

Another serious feature of some furnaces which are on the market, is the confined fuel area; this, in the case of one particular furnace, is so pronounced that the coke has to be broken up extremely small to permit its entry into the furnace, and even then it requires poking down repeatedly, much to the detriment of the crucible, or it will become lodged well up towards the top of the furnace and the fire will consequently creep up, owing to the coke at the bottom of the furnace being burnt away and no fresh supply of fuel reaching same, thus leaving a cavity, the blast playing through such cavity, and blowing the bottom of the crucible cold. This is certainly false economy.

For a crucible furnace to be effective, central heat must be maintained throughout the whole of the furnace, that is the burning gases must surround the crucible from the bottom to the top, and with the air supply coming from the bottom of the furnace this is impossible, for when we take into consideration that these gases always take the course of the least resistance and tend to rise vertically, it is seen that they will ascend and burn by the lining of the furnace, and so give more heat to the lining than to the crucible. Therefore, to avoid such course of the burning gases it becomes necessary to have the air supply coming from the sides of the furnace, but unless the pressure is very low and evenly distributed it has a cutting effect upon the crucible. Further, by having the blast or air supply coming from the sides, better provision may be made at the bottom of the furnace for collecting molten metal that would be deposited there, in the event of the crucible failing and so avoid damage to the furnace, especially when iron or steel is being melted.

Gas-fired crucible furnaces have not proved to be the success that was anticipated; the heat is too local and the cutting flame is extremely costly on the lining of the furnace or the crucible. Low-pressure gas furnaces are, however, very suitable for metal and alloys of low-melting point, such as aluminium and zinc and their alloys, being easily regulated and requiring little attention.

Oil-fired crucible furnaces have made rapid advancement, but the cutting flame that is always obtained in these furnaces is extremely destructive to the lining or the crucible, and is a matter that will be always difficult to avoid.

Air Furnaces.

The reverberatory or air furnace is a simple structure, generally built of fire brick, in which the fire is at one end and the flame from the burning gases passes over the metal which is to be melted. The roof is generally double arched so that it dips very much in the centre and throws the flame down on to the metal, thus tending to protect the metal from oxidation. The fuel used is coal, as it gives a long flame and a dry ash which does not clinker up the bars of the fire.

The fire itself is built on firebars or a grate, and is so constructed that a fairly deep fire can be kept, so avoiding an excess of air getting into the melting chamber.

As a melting furnace, the reverberatory furnace is very slow, and has a high fuel consumption, but these features are not so serious when it is taken into consideration that this class of furnace is only used for large quantities of special quality cast iron or non-ferrous alloys and metals that could not be melted so conveniently in any other way. As a metal melter the air furnace, therefore, cannot compete with the cupola in cost, but as the atmosphere of the air furnace can be almost entirely under control, and that of the cupola is so uncertain, the quality of the product from the air furnace far exceeds that of the cupola. Again, in the case of iron, samples of the molten metal can be taken and cast into a chill, and if not satisfactory, the necessary alterations of the composition can be made either by adding ferro-silicon if the metal is too hard, or increasing the draught of the furnace so that a clear, bright flame is passing over the metal, indicating an oxidising atmosphere, which will reduce the quantity of silicon and so harden the metal.

The regulating of the draught of the air furnace is not done by sliding metal dampers in the flue, as is common with pit flue fires, but by fitting the ash-pit with doors which open outwards, and can thus be readily adjusted to regulate the current of air.

When copper, gun-metals, brasses, or bronzes are being melted the furnace must always be worked with a smoky flame, which indicates that there is a shortage of air in the furnace, and oxidation of the metal can take place. This, however, means an increased fuel consumption, but the additional cost of the fuel is more than balanced by the quality of the metal obtained. When working with a smoky flame, on opening the fire doors the atmosphere of the melting chamber clears, and the metal may be examined through the "peep hole," which may be formed by a small hole through the side, plugged with a loose brick, and the joints seamed with wet sand.

When the air furnace is worked continuously, as in the malleable foundry, when three or four heats are taken off each day, the fuel consumption is much reduced by making use of the heat of the previous charges. Also, small air furnaces of about 1 to 2 cwt. capacity are often used to advantage in brass foundries, and by continuous melts the fuel consumption may be reduced to a much lower ratio than that of the pit fire crucible furnace and the elimination of the crucibles further reduces the total cost of melting. But when put to such use the ladles must be extremely hot, as the quantity of metal is so small that it rapidly cools.

QUEBEC BRIDGE.—The new Quebec Bridge, now approaching completion, was mostly built up from carbon steel shapes, but about 27 per cent. by weight is nickel steel. Among the nickel steel members are the trusses of the suspended span; a large portion of the cantilever trusses, such as the bottom chords and those web members in which it was deemed advantageous to use nickel steel without the sections becoming too small in consequence; the eye-bars of the suspended span, and the bottom wind bracing of the cantilevers.

Pyrometers and Pyrometry.

At a meeting of the Faraday Society, held on November 7, a series of Papers was submitted for discussion bearing upon the subject indicated above. Abstracts are appended :—

Notes on Pyrometry from the Standpoint of Ferrous Metallurgy.

By Dr. W. H. Hatfield (Sheffield).

The author feels that he cannot do better than deal with the subject from the steelworks standpoint. One important section of the Brown-Firth Research Laboratory is devoted to the standardisation and maintenance of the pyrometers used throughout their different works, and one of its functions is to follow closely the development of pyrometry. These notes may therefore be taken to indicate their point of view as regards the most useful types of instruments for different purposes.

All operations, melting, forging, rolling, annealing, hardening, tempering, etc., are best executed within some particular range of temperature, owing either to the influence of such temperature upon the actual operation or upon the subsequent properties of the material. In the first place the most suitable range of temperature must be determined, and then subsequently efficient means must be found for accurately repeating, for an unlimited number of times, the treatment so determined. For the investigatory side of the work, temperature readings should be preferably in absolute values; for industrial processes the instrument need not necessarily give such values directly, but those actually recorded should be readily transposed into absolute values.

The Measurement of the Temperature of Molten Steel.—Although the temperature at which steels are cast must have an influence upon their ultimate physical properties, no ready and really reliable method for measuring such temperatures from the works standpoint is available. This is a considered statement. It would obviously be of considerable use if the temperatures of successive heats of steel could be controlled and determined. The author has carried out experiments with a number of heats by means of the thermo-electric pyrometer and also with the Cambridge optical one. The ptical pyrometer was sighted upon the steels running into the ladle, and, to take one or two instances, the values obtained were in the neighbourhood of 1,400 deg. C. to 1,410 deg C. (low and high range scales for the same instrument.) Turning now to the comparative readings with the thermo-couple pyrometer, a couple was placed in position in the empty ladle prior to the steel being run in. As the steel gradually filled the ladle the temperature indicated by the thermo-couple increased until the couple was thoroughly immersed in the molten steel. The steel now was tapped from the ladle, the metal receding until the couple was quite free from the molten steel. By this means a time-temperature curve was obtained in which a flat maximum range was observed, corresponding to the temperature of the steel whilst in the ladle. The values so obtained ranged from 1,600 deg. to 1,625 deg. C. These values are not put forward as absolutely correct temperature determinations, as extrapolation beyond 1,400 deg. C. is still a matter of some uncertainty with these couples, but it is believed that the figures stated are reasonably correct.

Whilst dealing with the question of molten steel it may be of interest to record that with the thermo-couple method the freezing temperatures of steels have been industrially determined by us, and that, for instance, with a 0.1 per cent. carbon steel the temperatures so obtained are 1,480 deg. to 1,485 deg. C., such values being in sufficient conformity with the present iron-carbide diagram.

Annealing Operations.—Whilst the thermo-electric pyrometer forms an accurate, convenient, and easily adjustable instrument, sufficient attention is not always given to the manner in which the couple is placed relative to the steel. This comment really applies to all operations which involve the heating up of masses of steel. It is their practice to determine time and temperature data which will give practical information for the man in charge of the operation, by putting through experiments with masses of the same size. In such experiments one thermo-couple is placed inside the mass, whilst another is placed outside. In the hardening of high-speed steel an optical pyrometer intelligently used or a properly standardised platinum-platinum-rhodium thermo-couple adequately meets the case.

The Heating of the Mass of Steel.—The physical characteristics of the material which are involved in the question of the velocity of heat penetration are its thermal conductivity, its specific heat and its density, which between them furnish the quantity referred to as the " diffusivity " of the material. It is found by experience that the time required to heat up and thoroughly soak a given mass varies considerably with the nature of the material, as well as with its shape and dimensions. It is very desirable for many purposes that we should be able to predict the thermal condition of a mass at any given time from the commencement of heating. By its condition is meant the existing temperature at all points throughout the mass. From Dr. Harker's experiments it appears that the specific heat of nearly pure iron increases steadily from 0.1175 at 200 deg. C. to 0.1647 at 850 deg. C., beyond which temperature there is a slight decrease. Similar information for steels and various alloys is at present very meagre, and there is room for much further detailed research.

A very simple method, suitable for comparative tests, is that adopted by Mr. A. Johnstone, B.Sc. He employed his apparatus for measuring changes in thermal conductivity which takes place when the material is stressed. A known amount of heat is supplied at the centre of a wire, whose ends are kept at a constant cold temperature. The temperature gradient along the wire is measured. Mr. Johnstone has shown that in these circumstances, with the dimensions of wire employed, simplified calculation is obtained by making very slight approximations, which are equivalent to neglecting the amount of heat radiated from the wire under test. An apparatus constructed on this principle, but in which the proportional radiating surface was still further reduced, has been used at the Brown-Firth Research Laboratory, and it may be of interest to quote some of the results. The samples tested were bars 1 cm. diameter, and the fall of temperature along the bar was measured by

copper-eureka thermo-couples. A few of the results obtained are :—

Material.	Relative thermal conductivity.	Relative electrical conductivity.
Wrought iron	100.0	100.0
0.9 per cent. carbon steel, as rolled	65.3	58.4
25 per cent. nickel steel... ...	25 8	12.25
Air-hardening nickel-chrome steel, as rolled	40.6	34.5
High-speed steel, as rolled ...	38.0	36.2
High-speed steel, hardened ...	28.8	17.2

These results are only at room temperature over a range of 10 deg. C. to 40 deg. C., and the electrical conductivities are given for comparison.

The Advantage of Burying the Cold-Junction of a Thermo-Couple as a Means of Maintaining it at a Constant Temperature.

By Robert S. Whipple, M.I.E.E.

Although thermo-couples have been frequently buried for the purpose of measuring earth temperatures, yet they have not been buried for the purpose of maintaining the cold-junction of a thermo-electric circuit at a constant temperature. In the research laboratory, where accuracy is aimed at, it is customary to immerse the cold-junction in melting ice. As it is generally difficult to maintain an ice vessel near a furnace, this necessitates the placing of the ice vessel some distance from the source of heat. In the laboratory, where the cost of the wires for the rare-metal thermo-couples was not very serious, and where the furnace employed was small, this was not a matter of great importance; but in the works, where a large number of couples are used and where long lengths of leads are required, the employment of melting ice is impossible. The difficulty has been overcome to some extent by the use of thermos-flasks, and it is now no uncommon sight to see an installation of thermos-flasks mounted near the furnaces of a large works. In practice the flasks are filled with oil, in which the cold-junction of the thermo-couple circuit, together with a mercury thermometer, are immersed, the thermometer being a ready means of showing the temperature of the oil. Experience shows that in the majority of cases the daily temperature range indicated by the mercury thermometer does not exceed 2 deg. C., although the daily temperature range of the air surrounding the flask may amount to 10 deg. or 15 deg. C.

The introduction of Peake's compensating leads has rendered it possible to transfer the cold-junction of a platinum-platinum-rhodium or iridium couple to a considerable distance from the head of the pyrometer, so that the employment of a buried cold-junction with the rare-metal couples is rendered commercially possible.

The high price of platinum and its alloys has compelled the use of base-metal thermo-couples, and the reliability of some of the modern elements, such as the (1) nickel, nickel-chromium, (2) iron, nickel-copper, or (3) copper, nickel-copper, justifies the use of these elements to a high degree of accuracy. The materials mentioned are not expensive, and at once open up the possibility of burying as a means of maintaining the constancy of the temperature of the cold-junction.

The buried couple has proved successful in works practice, and it may be of some interest to show the method of burying the couple in one of the most successful installations. A steel tube closed at one end is buried in a small earthenware drain-pipe to a depth of 10 ft., the space between the pipe and the tube being filled with bitumen. The copper lead wires are soldered to the compensating leads or other leads from the thermo-couple, thus forming the cold-junction of the circuit. The joint is then protected by an insulating material, such as bitumen, and a lead cap soldered to the outer lead sheating, protecting the thermometer wires. The two cables are then pushed to the bottom of the buried steel tube, the tube as far as possible being filled up with either hot bitumen or powdered magnesia. It is sometimes convenient to fit terminals on the head of the tube in which the cold-junction is buried, or to construct the cold-junction arrangement in the form of a thermometer in which the protective sheath is driven into the ground. Buried junctions are being used in connection with an installation of thermo-couples measuring temperatures in an explosives factory.

In conclusion, it may be stated (1) that the temperature of the cold-junction of a thermo-couple system, if buried to a depth of 10 ft. beneath the floor of a fairly large building, will remain constant to within less than 2 deg. C. throughout the year; (2) that if Peake's compensating leads are used with platinum-platinum-rhodium couples there is no practical difficulty in using the buried cold-junction in a works. If base-metal couples are used, the problem is even less complicated, as simpler means of protecting the couple can be employed, the couple generally being more robust and the accuracy required being of a slightly lower order.

Base-Metal Thermo-Electric Pyrometers.

By Chas. R. Darling, A.R.C.S., F.I.C.

Base-metal couple possess distinct advantages. One of these is the development of an e.m.f. several times as great as that given by a Le Chatelier couple of platinum and platinum-rhodium alloy, which enables more robust indicators and recorders to be used, or a more exact reading to be taken over a given range. Another is that the pyrometer itself may be strongly constructed, and thus made less liable to injury in workshop use. Although inferior to the Le Chatelier couple with respect to the temperature range over which they may be used—the upper limit being 1,000 deg. C. for continuous use—base-metal couples still enable temperatures to be measured which comprise many industrial processes, such as hardening, tempering, and annealing, and have proved satisfactory in practice for such purposes.

The couples commonly employed are iron-constantan; two iron-nickel alloys of different composition; and two different nickel-chrome alloys, known as Hoskins' alloys. In some cases iron alloys containing aluminium are also used, the couples chosen being such as to yield a relatively high e.m.f., increasing uniformly with temperature. Some of these alloys tend to change on heating continuously, in such a manner as to alter the e.m.f. of the couple, and so seriously to affect the calibration of the scale. This danger may be reduced to a minimum by the careful selection of the alloys used, and due care in their manufacture; my own experience of British base-metal

pyrometers is that they are quite reliable if used within the prescribed limits.

Up to the present, no base-metal couple has been brought into use capable of being used continuously at temperatures above 1,000 deg. C.; and it has consequently been necessary to use a Le Chatelier couple, or a different type of pyrometer, for higher ranges of temperature. The object of this Paper is to suggest a means of extending the range over which base-metal couples may be used, by utilising the e.m.f. developed by a junction in which one or both of the metals may be in the liquid state. This is rendered possible by the fact that metals such as tin, aluminium, and copper, which could not be used in an ordinary pyrometer in which fusion would destroy the couple, might be used up to temperatures approaching their boiling points if the junction were maintained. The boiling points of many common metals are sufficiently high to indicate that a temperature of at least 1,500 deg. C. might easily be read by the aid of liquid couples.

The question immediately arises whether metals in the molten state develop an e.m.f. suitable for pyrometric work. The matter has formed the subject of an investigation by the author and A. W. Grace, and the results so far obtained indicate that in general the thermo-electric properties are unaffected by fusion, and that a temperature-e.m.f. curve shows no discontinuity at the fusion point. Exceptions to this rule are furnished by bismuth and antimony, both of which show an abrupt bend in the curve at the melting-point. It would therefore appear possible to measure temperatures by the aid of fused couples, and all that is necessary to apply the method in practice is to produce a working pyrometer on these lines. Experiments directed to this end have been hindered by many causes, chief amongst which has been the difficulty of obtaining suitable refractories shaped to meet the requirements of the problem.

High Temperature and its Measurement.

By E. F. Northrup (Trenton, N.J., U.S.A.).

The Measurement of High Temperature.—We must here confine our remarks to the measurement of high temperature by means of direct insertion pyrometers, excluding from consideration the extensive subjects of radiation and optical pyrometry. The limits to accuracy set for high-temperature direct-insertion pyrometers are determined chiefly by the inevitable chemical modification of the pyrometric substance rather than by its fusion or destruction. With the best types of pyrometer-casing tubes which are at present obtainable, at a temperature in the neighbourhood of 1,350 deg. C. gases obtain access to the thermocouple wires, and contamination is produced by the chemical activity of the hot gases. If the pyrometer is inserted in a reducing atmosphere, this contamination is particularly marked. Thus the writer has never been able to use successfully, except for very intermittent service, a plantinum-rhodium thermocouple in a reducing atmosphere much above the melting point of nickel. A thermocouple of tungsten-molybdenum, though giving but a feeble e.m.f., can be used to measure extreme temperatures if it can be protected from access of hot gases.

Up to about 1,300 deg. C. the accurate measurement of temperature in any kind of atmosphere has been satisfactorily solved by properly constructed and protected platinum-rhodium thermocouples, the e.m.f. of which is determined by a potentiometer method. As a potentiometer is a somewhat delicate instrument to take into the factory, and as a direct deflection galvanometer, or millivoltmeter, must be intrinsically sensitive to measure the feeble e.m.f. of a platinum-rhodium couple, the writer deemed it highly desirable to devise a robust portable instrument which would operate on the potentiometer principle, but give readings in millivolts or degrees by the deflection of a pointer. The instrument devised for this purpose has the appearance and all the rugged characteristics of a voltmeter. It is marketed under the name "Northrup Pyrovolter."

Some of the advantages secured with this type of instrument for measuring millivolts by reading a deflection, and consequently the corresponding temperature indicated by either a base or noble metal thermocouple, may be enumerated as follows: Sufficient sensibility is secured in a rugged instrument so that temperatures indicated with platinum-rhodium couples may be read with satisfactory accuracy. As the instrument operates on a potentiometer principle, the resistance of the thermocouple itself and the thermocouple leads may vary within wide limits without affecting the accuracy of the readings. The instrument is not limited to a single range, but as many as four ranges may be conveniently embodied in one instrument. The indications of the pyrovolter are theoretically and practically independent of the temperature coefficient of the instrument itself.

Though thermocouple methods of reading temperatures meet most of the requirements of laboratory and factory up to the safe working temperature limit of the plantinum-rhodium couple, there are many industrial operations, carried on at higher temperatures, where a direct-insertion pyrometer which measures these accurately would be very welcome. Nature has provided us with a pyrometric substance which promises to give the result desired. This pyrometric substance is the metal tin. It possesses among the metals some unique characteristics. Tin melts at 232 deg. C., and the writer knows from personal study that it does not evaporate appreciably nor boil at 1,680 deg. C. According to a determination by Greenwood its boiling point is 2,270 deg. C. Thus the range of temperature in which tin is molten, about 2,000 deg. C., is greater than of any other known substance. Tin does not form a carbide in the presence of graphite, and maintains its purity in an atmosphere of CO at the highest temperature at which it is molten. To these properties are added others which particularly adapt it to pyrometric uses. Thus, it increases in resistivity when in the molten state, and also in volume in a strictly linear manner within increase of temperature. At least this is true up to the highest temperature at which accurate observations have been made, which is 1,680 deg. C.

The writer has taken advantage of these characteristics of pure tin for measuring temperatures above 1,600 deg. C. and as low as the solidification point of tin. He has used a method employing the increase in the resistivity of tin with temperature, and has developed in this connection an instrument called a "resistometer." More recently he has developed a tin pyrometer which

depends for its indications upon the linear expansion of tin. The instrument is constructed on the general lines of a very large mercury thermometer. The upper obtainable limit of temperature to which it is practical to go has not been actually determined, but it is known from personal observation that this limit is higher than 1,680 deg. C., and it is thought to lie well above 1,800 deg. C. This pyrometer does not indicate, as a thermo-couple does, a point-temperature, but registers the mean temperature over the space occupied by the pyrometer bulb.

The Automatic Control and Measurement o High Temperatures.

By Richard P. Brown (Philadelphia).

Probably no employee has caused the average works manager to have so many sleepless nights as the furnaceman, on whose shoulders rests the reponsibility for the accurate heat treatment of the steel and the uniformity of product. The old furnace-man, through years of practice, will endeavour to gauge the temperature of the furnace with his eye. Providing he has not been up all the previous night, and his eyes clear, he will probably judge the temperature fairly accurately. If he is of a reasonably kindly disposition, he may permit the manager to install pyrometers to guide him in controlling the temperature, and he may even in time use the pyrometers and rely on them.

My experience in the United States has shown that for industrial service an instrument actuated by the expansion of nitrogen gas is the most satisfactory for temperature measurements up to 800 deg. F. or 425 deg. C. The gas-expansion instrument consists of a bulb of copper which is inserted in the heat, and this bulb is connected by capillary tubing to an indicating or recording gauge containing a helical expansive spring. The expansion of gas in the bulb exerts a pressure in the capillary tubing, which is conveyed to the spring in the instrument, and the pointer attached directly to this spring moves across the scale or chart. It is essential in this instrument that the capacity of the bulb be some fifty times as great as the capacity of the capillary tubing and spring. This is essential so as to reduce to a minimum errors due to atmospheric changes in temperature along the capillary tubing or at the instrument. In consequence this instrument is not desirable for use where the gauge must be placed more than 100 ft. from the bulb.

For use at moderate temperatures, where the measuring instrument must be placed at a considerable distance, and for temperatures above the range of the gas-expansion instrument, the thermo-electric pyrometer has been almost universally adopted in the United States. A thermo-couple of base metals, usually formed of one wire of nickel 90 per cent., chromium 10 per cent., and the other wire 98 per cent. nickel and 2 per cent. aluminium, is preferred for temperatures to 1,800 deg. F. or 1,100 deg. C. For temperatures above this, and as high as 2,800 deg. F. or 1,500 deg. C., thermo-electric pyrometers using a platinum-rhodium thermo-couple are the most satisfactory. For higher temperatures still, a radiation type of pyrometer is available, consisting of a thermo-couple in the focus of a reflector at the end of the tube, which is pointed at the door or opening of the furnace.

For even greater precision in temperature measurements than is secured with the high-resistance milli-voltmeter, I have developed a new instrument, which we call the Brown Heat Meter. This instrument is suitable for either temperature measurement or automatic control of temperature.

The extensive use of pyrometers to measure or record high temperatures will serve (1) to eliminate guesswork as to the temperature; (2) to reduce fuel consumption through the maintenance of the correct temperature and not excessively high temperatures; (3) to reduce time for heating of the product due to the maintenance of the correct temperature; (4) to increase efficiency in operating a plant through the savings outlined above. Instruments to control automatically the temperature, when properly constructed and applied, will eliminate entirely the personal element. The maintenance of the correct temperature in the furnace is automatic, and this is one step further, and in consequence an improvement over temperature control through pyrometers.

The Measurement of High Temperatures by Means of Pottery Materials.

By Henry Watkin (Stoke-on-Trent).

In the course of this Paper the author traced the origin and development of Seger cones as heat indicators, and showed how, in about the year 1898, the mixtures of which they were composed were made up into bars instead of cones, which, suitably suspended in a refractory case, were more easily read or observed by the sagging which took place during firing when a temperature was reached which produced the same, unlike the Seger cones, which sometimes leaned in the direction of vision, and consequently the distortion was concealed. A still further use was made of this principle by the adoption of the heat recorders and discoverers by the author in 1899. The recorder was simply a block of very refractory ware, with five circular recesses sunk into its top face. In these recesses were placed little pellets of fusible materials of definite composition and melting-point. The fusion-point of each mixture had been carefully and accurately determined by comparison with a standard electrical pyrometer. When specially designed for simply recording temperatures attained in parts of ovens, etc., inaccessible to observation, these recorders might also be used with advantage as pyrometers. The author pointed out that they had proved very useful as such to many industries, including gasworks, glassworks, engineers for annealing furnaces, smelting furnaces, rolling mills, enamellers, etc. All these forms of pyrometers, which were based on the principle of the softening-points of ceramic mixtures, were extensively used for industrial operations where high temperatures were necessary. They had, however, a serious limitation, since they did not register the length of time at which the heat remained at any particular temperature during the firing.

Discussion.

The Chairman, Sir Richard Glazebrook, F.R.S. (Director of the National Physical Laboratory), after a brief historical *résumé* of the connection of the National Physical Laboratory with the subject, said cases were frequently coming before his notice in which difficulties of a metallurgical character were obviously due to uncertainty in the measurement of high temperatures.

Dr. Walter Rosenhain said that a difficulty in

connection with Dr. Whipple's buried cold junction was a thermo-electric effect at the terminals where the wires leading down to the buried cold junction were connected on to the wires leading either to the galvanometer or to the thermo-couple, unless the connections were of identical metals. That would have to be guarded against. Difficulties would also arise in works, and the distance away from the furnace would in many cases have to be considerably more than 10 ft.; probably nearer 30 ft.

Mr. S. N. Braysbaw said that about 15 years ago Dr. Whipple supplied him with a copper-tin alloy which had a freezing point at 738 deg., and he sent it to the National Physical Laboratory to be tested. It was then used frequently and again sent to be tested, and the certificate said that no difference could be found in the freezing point. That showed it was a good standard. He then had a special deep graphite crucible made, and a pyrometer ¼ in. diameter. The top of the crucible was covered with an asbestos sheet with a hole through which the pyrometer could be passed. Arrangements were also made for gas to be always passing into the furnace, so that in conjunction with charcoal a temperature of 750 deg. could always be depended upon. A workman could be taught to use this as it took a very long time to freeze. The curve could be seen coming down, and then it stuck at 738 for perhaps a quarter of an hour before solidification took place. He had used that to standardise his instruments to about 1 deg. It so happened that commercial steel that could be bought by the ton containing 1.1 per cent. carbon and 0.5 per cent. tungsten also had the change point AC 1, 2, 3 at 738 deg., and that point was not moved by any ordinary commercial variation of the sulphur, phosphorus, silicon, or manganese. That was a very useful thing to know and to standardise from. He had taken thousands of standardisations from that steel which had the change point at 738.

Dr. R. S. Whipple said the error suggested by Dr. Rosenhain due to the thermo-electric effect at the terminals was bound to be small. The heat near the furnace was likely to be great, but the necessity of having to put the wires a long distance away had been overcome by various devices. He had long been hammering it into the furnace-makers that they did not make their furnace walls thick enough, and that there was always a great loss of heat in consequence. In regard to Mr. Brown's Paper, he had not been able to understand why automatic control had not been adopted. It was a perfectly feasible proposition. In one large steelworks the temperature of the hot air supplied to the blast furnace was controlled. Speaking from memory, the temperature was 700 deg., and the specification stated that the temperature must be constant within plus or minus 10 deg. C., and this had been conformed to for some years. A resistance thermometer was fitted in the main, which was about 2 ft. diameter, and there was a tube through which cold air was admitted, while hot air came up the other arm. In the cold air supply a butterfly valve was fitted, and at the commencement, when a new stove was switched on, the cold-valve was opened wide, and then gradually as the hot air from the stove cooled down the butterfly valve was automatically closed at the cold pipe. That was an example of control which was working very well. He knew another one where a large soldering iron weighing 36 lbs. was kept at constant temperature by means of a thermo-couple to within 3 or 4 deg. C.

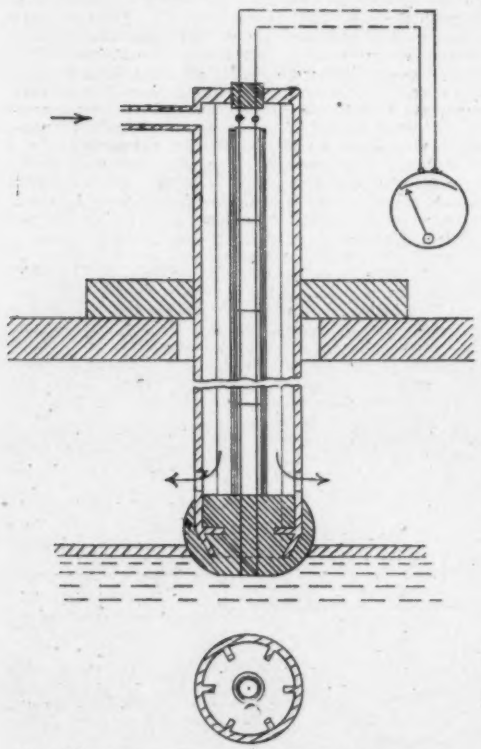
Prof. O. Arnold, speaking on pyrometry, applied to the hardening of high-speed steel, said it was a matter of general knowledge that steel metallurgists, in hardening high-speed steel, had come almost unanimously to the conclusion that the best average temperature to harden from was 1,300 deg. For regularity of temperature there was nothing so efficient as the salt bath. High-speed steel was generally hardened in a bath of barium chloride melted by two iron electrodes to a state of fluidity, and by adjusting the current a temperature of very nearly 1,300 deg. could be maintained. Several researches had been made at Sheffield, the results of which had not hitherto been published. A simultaneous set of observations were taken with five different pyrometers, viz., the Féry thermo-electric, Féry's spiral spring, the Foster base-metal thermo-couple, the Leskole optical or modified Wanner, and the Mesure and Nouel, and the results showed how the personal equation entered into such investigations. He had been much astonished at the good results obtained from all these pyrometers, which had almost led him to the conclusion that, properly used, whatever type of pyrometer was adopted, reliable results could be obtained. At any rate, the results rather pointed to the fact that many failures were due to lack of skill of the operators. In these experiments he was aiming at a mean temperature of 1,300 deg. C. before quenching, and the mean of the results obtained with all the five pyrometers was 1,296 deg., the differences in almost every case being such as might be due to slight variations in the instrument, but more, he thought, to the personal equation of the observer. He secured black-body conditions throughout, and that might have something to do with the remarkable agreement of all the results by these five different pyrometers. In a second case three pyrometers were used, and there were bigger variations. Again they were aiming at 1,300 deg., and the mean was 1,305. At the present time it was very important to obtain a constant record of the temperature of steel tapped from the open-hearth furnace which was a very difficult matter, particularly in a large furnace. Therefore, it might be well if he included a few results obtained from a 2-ton Siemens furnace in the Sheffield University. These temperatures were taken in December, 1910, with the old original Wanner pyrometer. It was usual to charge a Siemens furnace with what was called a "pig melt," to consolidate the bottom after repairing it when starting from cold. In this small furnace the pig melt was hematite iron of only half a ton, which was melted and kept pretty hot, cast into the ladle, and then allowed to cool somewhat, because they were going to utilise it for casting floor plates for the furnace. They cast five plates weighing 1¼ cwt. each, and the casting temperature of each was taken very carefully. As the charge was small even for the small ladle used, radiation would be pretty rapid. The casting temperatures were 1,300, 1,280, 1,243, 1,258, and 1,208 deg That represented a mean fall of temperature during the casting operation per plate of only 18 deg., and was the record at the Sheffield University. In December, 1914, another set of temperature readings were taken with Leskole and Mesure and Nouel pyrometers, and in this case the casting temperature was very high—1,525 deg. for the first plate, which was possible for pig-iron, although he doubted it. The figures for the five heats of structural steel plate, carbon about 0.35 per cent., were 1,600, 1,550, 1,630, 1,570, and 1,620 deg. Using the same pyrometers a third melt was made in March, 1915, and the casting temperature registered was 1,440 deg. for the Siemens hematite pig melt, which he thought was near the mark. The five heats were 1,625, 1,600, 1,600, 1,590 and 1,600 deg.

Dr. F. Rogers was not satisfied either with radiation pyrometers or with optical pyrometers for the investigation of the melting of steel. Recently he had had considerable success with a thermo-couple actually immersed at its ends into the molten metal through the roof of the furnace. He had got a perfectly steady reading of 863 for about two minutes, which worked out to 1,520 deg. That was an alloy steel. He had since worked it in the Siemens furnace—a 70-ton acid furnace—and the pyrometer in that case was 9 ft. long. He got a steady reading at 820, and as the pyrometer was pulled in and ont of the metal so the pointer went back to zero. In order to make it more practical for the Siemens furnace, which might run up to 1,700 deg. temperature, he had devised an arrangement of air-cooling for the sheath enclosing the wires.

Use of Thermocouples.

In his contribution to the discussion on "Pyrometers and Pyrometry" at the meeting of the Faraday Society, Dr. F. Rogers made reference to his successful application of a new method in the use of thermocouples for testing the temperature of molten metals. Subjoined are fuller particulars of this method, together with an illustration, for which we are indebted to Dr. Rogers.

The ends of the thermocouple wires have refractory material (clay or moulder's compo, etc.) moulded about them and firmly into contact with, and even over, the end of the sheath. The ends of the wires are not united to form a thermocouple, but they are placed in contact with the molten metal. A perfectly steady reading is instantly obtained, and in the majority of applications the pyrometer can then at once be withdrawn before the stem becomes heated sufficiently to damage it, although in actual tests of several minutes' duration the pyrometers had not failed. Merely the tip is heated to the temperature to be measured, and possibly the wires melt or alloy with the molten metal for a very short length, perhaps 1-16 in., but the electric circuit remains continuous, and the net effect corresponds to what would be given by a thermocouple of the two wires simply, under otherwise similar conditions. When the stem of the pyrometer is exposed to flame, as in the open-hearth furnace, it may be air-cooled. The air enters the sheath near the head, and blows out through holes a little above the end. All trouble with the cold junction is very conveniently avoided in this type by simply placing the cold junction inside the sheath near the air-blast inlet.



Method of Employing Thermocouple.

Dr. Rogers said he had not yet made a thorough calibration of a pyrometer of this type, but gave the following examples of readings obtained in trials. In each case a galvanometer was used whose readings, when used in the ordinary way with the thermocouple, were approximately correct, and for the trial the resistance stated was used in series. In the final column was given the temperature calculated from the ratio of the resistances, but this, he said, was not necessarily a very accurate idea of the temperature:—

No. of trials	Nature of trial.	Resistance of galvanometer and ordinary thermocouple circuit.	Additional resistance in series.	Steady reading.	Temperature calculated from relative resistance.
		Ohms.	Ohms.		
1	Solidification of cobalt-chrom. high-speed steel, in crucible	132	100	863	1530
2	Solidification of copper (in open furnace)	132	100	600	1062
3	Temperature in 70-ton acid open-hearth steel furnace, during melting down.. ..	34	24	850	1450

In each of these trials the end of the pyrometer was actually immersed in the molten metal for several minutes (3½ minutes in trial 3), as they were intended *inter alia* to be of the nature of endurance tests. In trials 1 and 2 air-cooling was not used. In trial 1 the wires were in one outer sheath; in trial 2 they were in two separate sheaths. In trial 3 the stem was air-cooled and was about 9 ft. long, massive, and was clad with heavy clay sleeves. He (Dr. Rogers) felt every confidence that they now had a really practical and sensitive method of obtaining the temperature of the molten metal in the bath or in the crucible. This was essential for really complete control, for so long as the temperature in making open-hearth steel could only be effectually taken after tapping the furnace, they had then practically burned their boats; there were very few means of control remaining at that late stage. This was particularly important, not only in regard to teeming temperature, but as regards "condition"—that was deoxidation—of the metal.

The pyrometers did not need to be immersed for a long time in the molten metal. The trials recorded included the fairly long immersion in order to test the durability and reliability of the pyrometers, and he would emphasise the fact that in practice in the majority of cases it was sufficient to immerse the tip of the pyrometer for from 2 to 10 seconds only at a time. There was no lag with the naked wires in contact with the molten metal. It was possible to grind a layer off the tip of the pyrometer if ever one felt a doubt that it had been affected by use, and so get back to fresh material in a moment.

Ambulance and First Aid in Factories and Workshops.

By an Order (No. 1,067), dated October, 12, 1917, the Home Secretary has brought into operation certain arrangements in regard to Ambulance and First Aid at all factories employing twenty-five or more persons which belong to one or other of the following classes :—Blast furnaces, rolling mills, foundries, metal works, and copper works. With a few unimportant modifications, the Order follows the lines set forth in the preliminary draft.

A circular accompanying the Order (which came into operation on December 1), points out that its main object is to enable treatment of any injuries sustained in the course of work to be obtained at the earliest possible moment. In particular, it is sought by such treatment to prevent septic infection or blood poisoning following upon injuries which are slight originally, but if neglected frequently result in long periods of disablement. The use of means to prevent an injury leading to disablement or to enable an injured worker to return to his work as quickly as possible is in the interests both of the employer and the worker.

The general scheme of the Order includes (*a*) First-Aid Posts conveniently situated in different parts of the works, and (*b*) in the larger works a central Ambulance Room. The *First-Aid Post* is intended for the treatment of slight injuries which at present are habitually neglected, and minor accidents such as cuts and burns which, if treated, need not prevent the injured person from continuing work. It is important that every step should be taken to induce workers to seek treatment at once for any injury, however slight. One means to this end is to have the First-Aid Posts readily accessible in all work places, and the Order accordingly so requires. In factories where no Ambulance Room is provided, the First-Aid Post will also provide for preliminary treatment of more serious cases, *e.g.*, those requiring arrest of hæmorrhage, or First-Aid treatment of fractures, unconsciousness, etc., before removal to hospital or pending the arrival of the doctor.

The Ambulance Room is intended to be the main centre of treatment in the works, and will serve in particular for the preliminary treatment of more serious cases, and also for any subsequent treatment that may be required in cases dealt with at the First-Aid Posts. Supervision of minor injuries is not less important than their preliminary treatment, and injured workers should be instructed to report to the nurse or attendant at the Ambulance Room for re-dressing.

First-Aid Posts.—The treatment provided for is that set out in the First-Aid Leaflet (recently revised) issued by the Factory Department of the Home Office.

The construction and equipment of the First-Aid Box or Cupboard have been carefully considered in consultation with the St. John Ambulance Association and with manufacturers of such articles (from whom the boxes or cupboards fitted with the necessary dressings, etc., will be obtainable). The *sterilised* dressings should be in *dust-proof* packets. As the eye-drops recommended for use contain a proportion of cocaine (the purchase of which is now subject to special restrictions), the Home Office has issued a *general* permit which authorises any occupier to purchase these eye-drops for purposes of First-Aid treatment in his works. Application to the Home Office, therefore, for a special permit is not required and should not be made. Occupiers should have no difficulty in obtaining a supply if the order is given by the responsible head or manager of the works, and if a copy of the leaflet is produced to the chemist.

N.B—*The equipment of the First-Aid Box specified is the* MINIMUM *necessary. Where such boxes constitute the sole provision for treatment in the works, and no Ambulance Room is provided, the contents may with advantage be extended by the addition, for example, of scissors, safety pins, iodine solution, sal volatile, and a roll of plaster* (1 *inch wide*).

It will be convenient to post up near the First-Aid Posts in works where there is danger of electric shock a copy of the instructions as to treatment of persons suffering from electric shock, and in works where water gas, suction gas or gases of a similar nature are manufactured or used the placard issued by the Home Office as to treatment of persons suffering from "gassing."

Each Aid Post must be placed definitely in the charge of some one person, who will be responsible for seeing that it is kept stocked, and whose name must be posted in the workroom concerned. It is not necessary that he should be the person who will actually render first-aid in case of an injury, but it is obviously desirable that he should be—and it is hoped that employers will try to arrange for this in all cases if possible. Where the person considered most suitable has not already received a training in first-aid, it is recommended that the employer should arrange for him to take the course, and obtain the certificate of proficiency, of the St. John Ambulance Association or the St. Andrew's Association, or other recognised society or body. In many works special facilities for attending first-aid classes have been arranged by employers.

Ambulance Room.—In factories in which the total number employed is 500 or more an Ambulance Room is required. The equipment aimed at should be that of the out-patient room of a hospital. As the treatment carried out in the Ambulance Room will be in the hands of a medical man, nurse, or person trained in ambulance work, it has not been thought necessary to issue any instructions on the subject—beyond those as to first-aid treatment contained in the First-Aid Leaflet already mentioned.

The Ambulance Room will also usefully serve the purpose of a rest room for cases of fainting, sickness, etc., especially when supervision by the nurse is desirable The room should not, of course, be used for the purpose of a general rest room. Each Ambulance Room must be under the charge of a person with knowledge of first-aid treatment, and for this purpose a *trained nurse* is usually the most suitable person. A nurse who has had three years' experience in a general hospital would be thoroughly trained.

In some instances there may be difficulty, under present war conditions, in completing the arrangements for the Ambulance Room before the appointed date. Such cases should be brought to the notice of the Inspector for the district. Reasonable latitude will be allowed.

Ambulance Carriage.—The provision of a properly constructed ambulance carriage will enable the prompt removal from the factory of serious cases which cannot be treated, or can only be given preliminary treatment, on the spot, and will avoid any risk of the injuries being aggravated, as has often happened, by conveyance in a cab or other unsuitable manner. A motor ambulance is desirable, though not required by the Order. Where the works are near to a hospital a wheeled litter with rubber tyres would be regarded as suitable.

Accident and Sickness Record.—The use of a specified form for keeping the records required by the Order is recommended.

Medical Supervision of First-Aid and Ambulance Arrangements.—Occupiers are strongly recommended to arrange for some form of periodic medical supervision, say at quarterly intervals, of the First-Aid Boxes and Ambulance Room. This will help to ensure the efficient maintenance which is required by the Order, and will afford the First-Aid attendant or nurse an opportunity which they would appreciate of discussing with a medical practitioner the difficulties they are sure to encounter in their daily routine. In many works arrangements are already made for the treatment by a medical man of urgent cases; extension of this to

supervision of the First-Aid treatment in the factory would increase the efficiency of the *personnel* charged with carrying out the treatment, establish confidence in the measures adopted, and lessen the risk of neglect of slight wounds, with the consequence of lost time. Where medical treatment is not provided, arrangements might be made with the certifying surgeon to undertake the periodic supervision suggested. Advantage would also be gained by entrusting to this medical man the duty of training in the essentials of First-Aid a sufficient number of persons to secure that there shall be in each shop one or more persons capable of applying the remedies provided in the First-Aid Box.

Deoxidiser for Steel Baths.

J. I. Bronn, of Rombach (assignor one-half to Rombacher Hüttenwerke), has patented a substitute for ferro-manganese or other expensive deoxidisers to produce a workable steel. The oxygen-containing iron baths obtained at the end of the Bessemer or open-hearth process are deoxidised with a molten pig-iron high in phosphorus. Under certain circumstances it may be advisable to charge an excess of phosphorus, which can easily be removed by a short refining without appreciably reoxidising the metal. The deoxidising effect of the addition of basic pig-iron to the converter charge appears from the following comparative data relating to working with pig-iron containing 0.45 per cent. silicon, 1.20 per cent. manganese, 1.85 per cent. phosphorus and 3.5 per cent. carbon.

	Mn. Per cent.	P. Per cent.	C. Per cent.
Iron bath at end of blow ..	0 19	0.045	0.05
After addition of basic pig-iron	0.25	0.085	0.07

It is advisable to add the molten phosphorus-containing pig-iron in the converter after skimming in order to improve the intermixing. In connection with the open-hearth furnace the bath is refined as usual, and the iron rich in phosphorus added in the molten condition when the furnace charge is nearly finished. Care is to be taken that the slag is not very high in phosphorus, and that it is in as thin-liquid condition as possible. The following comparative percentages show the effect of the addition of basic pig-iron in this case :—

	Mn. Per cent.	P. Per cent.	C. Per cent.
Furnace charge (33 tons) after refining	0.26	0.030	0.10
Basic pig-iron addition (1.500 kg.)	1.75	2.78	3.5
Deoxidised bath	0.43	0.062	0.15

The bath shows an increase in the amount of manganese contained in the pig-iron addition, as under :—

The bath contained	330 × 0.26 = 85.8 kg.
And the addition	15 × 1.75 = 26.1 kg.
Total	111.9 kg.

The bath contained as above stated 0.43 per cent. manganese, or 148 kg., so that an increase of 36.1 kg. manganese has taken place. The phosphorus, on the contrary, shows a considerable decrease, as under :—

The charge contained	330 × 0.03 = 9.9 kg
The addition	15 × 2.78 = 41.8 kg.
Total	51.7 kg.

As the bath contained 345 × 0.062 = 21.3 kg., a decrease in phosphorus of 30.4 kg. has taken place which has been used for deoxidising purposes. These data relate to the pig and ore process. Similar results are obtained in connection with the pig and scrap process. If compared with the usual deoxidation process with ferro-manganese alone, the deoxidation with basic pig-iron rich in phosphorus results in saving 2 kg. metallic manganese or 4 kg. of 50 per cent. ferro-manganese for each ton of steel.

Non-Ferrous Notes.

Copper-Nickel Alloy for Hot Stampings.—The following, from "Metal Industry," relates to the making of cupro-nickel bars suitable for hot stampings :—Any proportion of nickel up to 25 per cent. may be used, depending upon the physical properties, *e.g.*, colour, tenacity, etc., of the finished article. Pure electrolytic copper should be used, Mond nickel, and 0.5 per cent. manganese (say 1.5 per cent. of 30 per cent. cupro-manganese). Melting should be done in graphite crucibles, using powdered glass as a cover.

Zinc Alloy Substitute for Brass.—A substitute for brass in electro-technics, as well as in opto-mechanical works, especially when the material is not brought into contact with acids or exposed to very high temperatures, is a zinc alloy, prepared by the Hohenlohe-Werke O.S. in accordance with a secret method, and mentioned in "Metal Industry." It consists of a technically pure zinc and contains in addition to traces of calmium and iron—about 0.16 and 0.017 per cent. respectively—not more than approximately 1.13 per cent. of lead. Its capacity of withstanding pressure varies between 1,600 to 2,300 kilogrammes to the square centimetre, its texture is exceptionally dense, and the appearance of its surface of fracture resembles that of steel. It is placed on the market in the form of round or flat rods or bars, about 4 millimetres or more in diameter and about 6 metres long, as well as in the form of tubes of an exterior diameter not exceeding 100 millimetres.

White Metal Bearings in Germany.—The white metal used for bearings on the Royal Prussian State railways (says a writer in "Metal Industry") consists under normal conditions of 83.3 per cent. of tin, 5.6 per cent. of copper, and 11.1 per cent. of antimony, its hardness according to the Brinell scale being 35. Recent researches have shown that in the case of brasses for connecting rods and axles which are not subjected to too great a strain, it is possible to use an iron-zinc alloy, consisting of 4 parts by weight of old fitters' brass, 21 parts of tin, 63 parts of zinc, and 12 parts of lead, showing a composition of 3.3 per cent. of copper, 21.3 per cent. of tin, 63.3 per cent. of zinc, and 12 per cent. of lead. The mixture, the hardness of which according to the Brinell scale is 42, does not flow so easily as the ordinary white metal, and must be cast in accordance with certain conditions. As on account of the large proportion of zinc it is very liable to excessive shrinkage, it is not easy to cast it satisfactorily round the shaft, and its use is consequently not free from objection. Entire brasses, capable of a high power of resistance, may be made from "Germania-white metal," which is capable of withstanding a pressure of 3,500 kilogrammes to the square centimetre. Its specific gravity is 7.5 and its melting-point 425 deg. C. This metal will have reached the temperature at which it can be cast to best advantage when the metal, the colour of which is a silvery white when liquid, begins to show a reddish shimmer, which may be taken as an indication of approaching incandescence. Another mixture, which has become known under the name "Erhard's warbronze," may likewise be usefully employed for similar purposes. It consists of 85 per cent. of zinc, about 9 per cent. of copper, 3 per cent. of aluminium with an addition of enriching substances. It has a strength of about 2,800 kilogrammes, a resistance to pressure of about 9,800 kilogrammes, and a hardness of 95 according to the Brinell scale. As its melting-point is about 450 deg. C., it is, like all alloys of zinc, not suitable for use with fittings exposed to hot gas or steam.

Casting Bearings.

In a paper presented at the annual meeting of the American Institute of Metals, on September 26, Mr. R. R. Clarke explained some methods of avoiding difficulties commonly experienced in moulding each of three groups of bearing metals; those containing less than 10 per cent. lead, those containing between 10 and 15 per cent. lead, and those containing between 15 and 50 per cent. lead. An abstract of his paper follows :—

Low-lead alloys, if the phosphorus and the ratio of tin to copper are held to safe limits, offer no great difficulty. The 80-10-10 alloy with ½ to 1 per cent. phosphorus is easily handled. It works best on second melting, though satisfactory results are obtained by combining and pouring direct. We have found that adding the tin and lead in combination to the copper bath together with vigorous stirring improves the product.

The sand for the moulds should be of good body and rather dry. Also, it should be tamped until hard, as this causes the metal to freeze rapidly. Facing the moulds well with plumbago has the same effect and also makes for smoother castings. The mould when of sufficient depth should be gated at or near the bottom and the metal should be poured at a low temperature, as hot metal favours lead segregation. Also, the castings should be left in the sand until cooled below the freezing point of lead. A horizontal moulding position with the journal core in the drag is preferred, although moulding castings, such as crown brasses in a vertical position or "on end," is sometimes countenanced. It is a method we have tried and discarded.

Products of medium lead content require the same measures. Phosphorus should be kept to a mere trace, melting and pouring should be done from medium sized rather than large crucibles and stirring should be vigorous and from the bottom upwards.

Practice with high-lead alloys varies only in a few details from that of low-lead alloys. The inclusion of phosphorus is prohibitive, the use of low-grade material is more markedly detrimental, and the constant building up of scrap with new material is more imperative. Cope shrinkage also is more pronounced and calls for higher and more powerful pressure gates.

Castings of high-lead content should be shaken out cherry-red rather than be left in the sand until cold, as this prevents excessive segregation. It is found that the metal casts as well using the direct method as by first pigging and then casting. When working new metal with scrap a good method is to first reduce the copper and then add the scrap, followed by the lead. High-lead alloys should not be subject to air and oil methods, at least not in the type of furnace we operate. Also it appears that the electric furnace is satisfactory. Regardless of practice, absolute exemption from segregation in high-lead alloys has not been our experience.

The chill-moulding idea applies chiefly to the crown brass variety of work embodying heavy duplicate castings. Locomotive driving-box shells are an example. They run from 50 to 200 lbs., and represent almost exclusively our experience in chill-moulding bearing metals of copper base. With metals of low or conservative lead content we have not had much success. With higher percentages fairly satisfactory castings are possible, though we do not consider these castings to equal the sand-moulded ones. They have a tendency to blow holes, shrinkage, and a most unsightly appearance. This latter condition arises from the lead sweating out and adhering in globules to the walls, these globules being broken off when the casting is removed from the mould. We also believe that the sand-moulded castings properly made are as free from metal-included sand as those moulded by the chill method.

Co-Operation in the Brass Trade.

Proposed Scientfic Bureau.

At a meeting of the Birmingham Local Section of the Institute of Metals, on Nov. 20, the Chairman, Mr. Stanley Evered, gave an address upon "Co-operation in the Scientific Side of the Brass Trade." He said that recently they had seen a great change in the attitude of the Government in regard to trade combines. That was perhaps because the meaning of the word "combine" had altered. The present meaning of the word, as he understood it, was a combination of firms primarily to reduce manufacturing expenses by specialised manufacturing, which, while ensuring good wages to the workpeople, would enable the manufacturer to produce goods at the lowest possible prices to meet the foreign competitor. Co-operated or united manufacturers had to decide what each should make, and then lay themselves out to make these articles in the best possible way. To do that would be wanted not only agreement among the masters, but also agreement and content among the men, and the help of every scientific device and every bit of scientific knowledge that was available. At the opening meeting of the Section last year he made a suggestion as to trade laboratories. They now had a practical scheme on foot, to be run partly by the Non-Ferrous Rolled Metal Section of the Ministry of Munitions, which Mr. Barclay represented, and six local firms, who previously had no laboratory of their own. Hitherto the local work of the Non-Ferrous Rolled Metal Section had been partly done in the Technical School by a special staff from the Ministry of Munitions. At a meeting between the technical Corporation staff, Professor Turner, and Mr. Barclay, it was decided that the present arrangement was not in the best interests of the Ministry of Munitions or the Technical School. The Non-Ferrous Rolled Metal Section of the Ministry would support them, and he believed that when they had their scheme cut and dried its finance would be assured. They would have to form a small limited company, making no profit, to meet the requirements laid down in the Second Annual Report of the Committee of the Privy Council on Scientific and Industrial Research. When they had run the laboratory some time they might be able to add to their numbers. If the Ministry of Munitions should not require the laboratory after the war they would be in a position to decide whether to take in more members to replace the Ministry or take over the whole. If large trade combines came about it was hardly possible that many large works would be closed up. The probability was that each would be a factory producing certain sections of the articles previously made in them. A co-operative laboratory would serve those sections excellently; much more efficiently than a laboratory in each section, and at far less expense to each. They wanted in addition a larger scheme to embrace all the existing firms having laboratories, and any allied laboratories, such as the Birmingham Corporation Gas Laboratory and their own Co-operative laboratories. What he proposed was a central body, which he would call "The Brass Trade Scientific Information Bureau," governed by a board elected by the co-operating interests. They would want a permanent staff headed by a first-rate metallurgist. He would suggest that if they got 100

manufacturers to support this scheme with a promise of £50 per annum they would have an assured success.

Mr. W. R. Barclay (Non-Ferrous Rolled Metal Section of the Ministry of Munitions) said in one case he knew a small firm which put down a laboratory and paid a chemist the munificent salary of £150 a year. When the laboratory had been going some little time the analyses were called in question, and there might have been a law suit. When inquiries were made by the managing director of the firm, he found that his chemist's results would not stand the rather lurid light of the Law Courts. How could he expect his results to be reliable with a laboratory run on such lines? These things were tragedies; they brought all scientific knowledge into disrepute. When he began to think of the problem presented by the firm with only £300 a year to spend, he thought here was a chance for a co-operative laboratory. The theory of a first-class, well-equipped works' laboratory was that it did not touch research at all. A great deal of the talk of research which was in the air at the present time was beside the mark. They were not ready for research till they had availed themselves individually and collectively of scientific knowledge.

General support was given to Mr. Evered's proposals by Dr. Brownsdon (King's Norton Metal Company) and Mr. H. L. Reason. Dr. Brownsdon, referring to cases mentioned by Mr. Barclay, said that there ought to be some means of disseminating the knowledge referred to. He did not think the Institute of Metals could take the task upon itself, though perhaps some other societies might do so. But there was no reason why publicity should not be given to this knowledge in some journal.

Mr. F. C. A. H. Lantsberry (Birmingham Small Arms) concurred generally with the previous speakers, but did not agree with Mr. Barclay that they were not ripe for research at present. There were many things discovered in works' laboratories which required further research before they could be made of practical use.

West of Scotland Iron and Steel Institute.

The first meeting of the new session of this Institute was held at Glasgow last month.

In his opening address, the President (Mr. Herbert Beard) referred to some of the problems confronting the iron and steel industry, and commented upon the circumstance that the Institute attained its semi-jubilee this year. So far as he could see, the most vital thing in connection with the iron and steel trades of this country at the present time was an increase in the production of pig-iron, and consequently of native iron ores. The output of native ore in this country had not increased in the last few years. Last year some 13,750,000 tons were mined, and very nearly 7,000,000 tons of other kinds of iron ore were imported—the bare requirements to maintain the annual production of pig-iron and other services. Transport difficulties in connection with the supply of foreign ores were not likely to be removed for some considerable time, and the supply of scrap was not likely to increase; it would be a wonderful achievement if the anticipations of the Ministry that at the end of 1918 the steel production of this country would be increased 50 per cent. over the pre-war output, were realised. The British steel industry had made wonderful strides during the course of the war, but it would have to get more ore, more pig-iron, and more scrap to keep its stride and to supply what was required to make up the shipping losses. Some people looked to the United States for relief, but so far as ship-plates were concerned only 5 to 6 per cent. of the American output of rolled iron and steel was available for shipbuilding purposes. We could absorb our own output easily. The facilities of the United States for shipbuilding not being so great as ours, a substantial proportion of their production might be diverted to this country for shipbuilding purposes in the future, though last year we did not get a tenth part of their monthly output of plates for shipbuilding. To make good the losses in shipping was one of the biggest tasks that had ever confronted the shipbuilders and steel manufacturers of this country, and it would tax the rolling capacity of the steel works to the uttermost for a long time ahead. If the United States could come in with 500,000 tons gross register a month, that would go a long way to solve the problem of replacing the shipping losses.

Industrial Research.

Following the Presidential address, a Paper on "Industrial Research" was submitted by Dr. Cecil H. Desch, who remarked that, great as had been our achievements in the past, the keen competition between nations at the present time called for more individual activity and co-operative organisation for the investigation of problems which presented themselves. The simplest arrangement they could have was for each firm to conduct its own research, but that was only practicable in large firms with considerable staffs. For efficient research they needed well-equipped laboratories, and staffs with leisure to work out problems; firms which were sufficiently large might be able to get a laboratory specially for purposes of research, and to employ chemists relieved from routine duties to develop investigation. That had been done in the United States and in Germany, but rarely in this country before the war. Such organisations involved great expense, and the example more likely to be followed in this country was for associations of firms engaged in the same industry to have joint laboratories. It was too much to expect individual firms to solve the problem for themselves, but if firms could combine to carry out investigation on a co-operative basis, then the future of the industry should be very much brighter. It was now well known that in that particular area a scheme was being drawn up, and he hoped that something tangible would be put forward.

PRACTICAL COURSE FOR FOUNDRYMEN IN AMERICA.—The Westinghouse Electric and Manufacturing Company, of East Pittsburgh, U.S.A., has recently established a course of foundry work for its employees between the ages of 17 and 31 years, who have passed a certain standard in their school education. The shop courses include the following:—Bench and floor moulding, machine moulding, core making, preparation of sand, cupola practice, mixing of alloys, and cost calculating. Classroom instruction will be given during the course on blue print reading, mechanical drawing, shop problems, and metallurgy, particular attention being given to the alloys of iron and copper.

LOSSES DUE TO RUST.—It is now generally admitted that the rusting of iron and steel is one of our serious problems. If we assume an average life of steel of thirty-three years, the depreciation charge of 3 per cent. represents, according to the United States Bureau of Mines, a yearly loss of 1,000,000 tons of product in the United States for the crude or semi-finished material alone, exclusive of correlated manufacturing costs. The inevitable rusting of steel may be justly claimed to be the mainstay of the zinc industry, as 60 per cent. of the metallic zinc used in the States is for galvanising iron and steel articles, representing an annual outlay of £4,000,000 in an endeavour to protect metals from decay. Enormous amounts of paint are used in a like endeavour. About 5,000,000 tons of coal are needed in the production of steel to replace the annual waste, and 1,000,000 more for replacing the zinc that is annually lost. No estimate can be made of the value of the brass, bronze, copper, aluminium, nickel, tin, and other metals and alloys used in machine parts, as sheathing, for plating, etc., to protect steel, or as a substitute for it in places where it would be used, but for its lack of resistance to atmospheric attack.

British Foundrymen's Association.

LANCASHIRE BRANCH.

The Training of Engineers' Apprentices.

Before the Lancashire Branch, on November 3, Mr. Key (Branch-President) in the chair, Mr. J. W. Lord, B.Sc. (Victoria University), read a Paper on "The Training of Engineer Apprentices." He approached the subject from the standpoint of a teacher, and described the various schemes of work and the methods adopted in the Newton Heath (Manchester) Junior Technical School, and of which he is the principal. He had found in his visits to various firms of engineers, that they each had their own way of dealing with the apprentices, in some instances employing them merely as producers, and taking no interest in their training; in others they were given no opportunity of learning anything beyond the particular work on which they were engaged; while in other cases, again, the boys were encouraged to make themselves acquainted with the technical details of the operations in which they took part. Only a few firms, however, seemed to have recognised the supreme importance of giving the apprentices a real training, and the latter, in consequence, never took the trouble to acquire the needful knowledge for themselves. Such being the case, it spoke very well for the trade, as a whole, that there should be so many skilled workmen belonging to it. The majority of the lads required very careful and constant supervision, because while certain portions of the work called for the exercise of little thought, other portions demanded a considerable amount of thought, if it was to be done satisfactorily. One day a man might be an organiser, while on the next his work was purely mechanical, requiring not only great bodily strength, but considerable manipulative skill. Taking into account the qualities demanded of the boy, he had come to the conclusion that much depended on his training both in the school and in the works; in fact, it was not so much a question of the information imparted to him, as what method should be adopted in imparting it.

The engineer naturally wished to have steady, reliable lads, who would in case of need attempt to solve difficulties for themselves, and to carry on a series of operations without constant instructions. That being granted, the methods to be adopted followed naturally The boys should be grouped in classes of about twenty, and the teaching should be not so much tutorial as practical, while the lessons should not exceed one hour. Instructions in mathematics, drawing, physics, history, etc., and physical exercises made up a syllabus of 38 hours per week. No boy was either pressed unduly forward or was kept back, and they were all given pieces of work to produce. At the Newton Heath School they did not specialise, their aim being to give the pupils a broad general education, and to train them in the subjects which were most likely to be useful to them later. They spent six hours during the previous week in workshop practice, but it was not at the expense of any other subject in the school time-table. Such work not only strengthened a boy's perseverance, but encouraged him to try and acquire greater skill than he already possessed, or was shown by older scholars. Care was taken to emphasise the bearing of the subjects they were taught upon engineering.

Having described in detail the kind of lessons given to the boys in the English language, in geography, mathematics, physics, drawing, and workshop practice, including the right use of tools, and the proper treatment of certain materials, Mr. Lord proceeded, that one hour per week was spent in physical exercise, games were organised, and matches at football between various classes or with other schools were arranged from time to time. Highly recommended boys ought to be afforded special opportunities for pursuing their studies, and further opportunities should be given them in the works of carrying on their education under the tuition of a thoroughly capable man. In that matter, the School had, on the whole, met with generous treatment on the part of many firms, especially those who took an interest in the future of their apprentices.

If Mr. Fisher's Education Bill were ultimately passed, it would be made compulsory for apprentices to attend certain day classes, and thus continue their education after leaving school, which was the most important point. It might become necessary to build separate schools, or groups of schools, for allied trades, the course of instruction to embrace mathematics (including costs), chemistry, metallurgy, English, etc., and youths should be able to obtain more advanced instruction in evening classes up to about the age of 18. Societies like the British Foundrymen's Association were simply invaluable, for it was to them education authorities had to look for advice as to the subjects in which boys should be instructed. He hoped employers would see the advantage of granting the concessions suggested, and thus allow the best boys certain periods of time every week in which to carry on their studies. Out of those there might, and would, be some who would desire to proceed to a full University course. But unless employers were prepared to be more generous, and some parents willing to make sacrifices, only lads with private means would be able to afford the cost of a University course. Something might be done in the way of scholarships, maintenance grants, or allowing a salary, and the young men themselves should do their part in the way of making sacrifices, but too much must not be expected of them. An intermediate technical school would also have to be established for the use and benefit of lads who attended evening classes, but who wished to carry forward their education further than they had the opportunity of doing at present.

Mr. S. G. Smith, speaking from experience, said they found that their first difficulty was in getting boys for the foundry; the second, was to keep them; and the third was to teach them. In his opinion they were not turning out the same class of moulders that they used to do very many years ago, while the old-time fitter had become almost obsolete. For the first two years the apprentice should be under the guidance of a qualified moulder. He had himself tried the experiment of giving a series of shop talks or lectures to the apprentices, with the result that the attitude of the lads towards their work was quite changed. He had not time to go fully into the question of the training of apprentices, and could only say he did not think the scheme of instruction outlined by Mr. Lord in his very interesting address would prove successful if generally adopted.

Mr. Peakman referred to the home life of many of the apprentices, the conditions of which prevented them from following up their studies in the evening, whatever advantages they might have

had in the school and in the workshop. When all the members of the family were crowded into one room, it was not possible for the boy to take up his book and study it properly. Suitable centres ought to be provided where such boys could pursue their studies to advantage.

Mr. Rowe asked where on earth they would get their moulders from if Mr. Lord's scheme of education was carried out? One of the finest moulders he ever knew was a man who could not write his own name.

A Member remarked that when a firm discovered they had got a good moulder they did not "throw him about the shop," but kept him at the job.

Mr. T. W. Markland believed that in the future the terms of indenture would have to be shorter. The task of making the boys into good workmen rested with the foreman, and the way to do it was to give them a good training in the shop, and to change their work from time to time.

Mr. W. H. Sherburn said that where an engineer wanted one boy who could solve difficulties, he wanted ten for other duties. Did it not seem a waste of time for a lad who had only to mind a machine when he went to work to learn all the various subjects mentioned by Mr. Lord? Those were the boys they had to deal with, and therefore, to that extent, he was disappointed with the Paper, because he had hoped it would have helped them in their efforts to solve the problem. They had heard a good deal that afternoon about preparing boys for apprenticeship, but in his opinion the best training ground for the apprentices was the works in which they were employed. When mechanical appliances were introduced into any craft, they ought to be used so as to help the craftsman, and not to make him into a mere labourer. The general tendency, he regretted to say, had been altogether in the opposite direction.

The Chairman believed that when the conditions of the trade were altered and improved, and apprentices were put through a proper course of training, they would be able to get lads into the foundry.

Mr. Lord, to whom a hearty vote of thanks was accorded for his Paper, maintained that the course of instruction he had described would benefit, not only a moulder, but any boy who might undergo it. The scheme had proved attractive in the case of very many lads who had passed through the school, and it seemed to him that in bringing home to them the attractive side of the work, they were most likely to make them feel an interest in it. He had been very pleased to hear the statement made by Mr. S. G. Smith that he had given a series of lectures to the apprentices of his firm, and with good results, for that, of course, was thoroughly in accord with what he had been advocating.

Casting Bombs in Green Sand.

The Lancashire Branch of the British Foundrymen's Association paid a visit on November 17 to the works of Messrs. J. Chadwick, Limited, Bolton, to witness the arrangements for casting the Newton bomb in green sand. Mr. Chadwick and his son conducted the visitors round the works and explained the various methods of procedure, as well as answering the many questions put to them by the visitors from time to time. Beginning in the department in which the shells were tested up to a pressure of 2,000 lbs.—the bursting point being 2,500 lbs.—they were next given a series of demonstrations in the moulding of the shells, showing the method of fixing the core in position in the box, by an ingenious mechanical contrivance which ensured absolute equality of thickness all round. The other sections inspected were: The drying stove for cores, the making of core boxes and machines, the moulds into which the cores were placed, dressing, grinding, inside cleaning, and the varnishing, painting and brazing.

Messrs. Chadwick afterwards entertained the whole party to dinner at the Pack Horse Hotel.

Mr. Roe, Vice-President of the Branch, remarked at the conclusion that he was sure they would all wish to extend to Messrs. Chadwick their very warm appreciation of the courteous and generous manner in which they had been treated.

Mr. H. Sherburn seconded the resolution, and Mr. J. Simkiss, in supporting it, said the majority of them were more or less fixed up with Government work, and knew therefore the difficulties attendent upon carrying it out. The work was indeed of the most exacting description, for the castings had to be perfect. The Government had appealed to the ironfounders, and he did not think the appeal had been made in vain, seeing that not very long subsequently the munitions were in the hands of the men at the Front. (Applause.) The operations had no doubt entailed a considerable outlay on new plant, and in other directions, but the object had been attained in the end, namely, the manufacture of an efficient shell made cheaply and expeditiously, and in large quantities.

Mr. Hill suggested to the officials of the Branch the advisability of forming a special technical committee to undertake propaganda work on a systematic basis, instead of leaving it to be done, as it were, at haphazard.

The resolution having been carried by acclamation, Mr. Chadwick, in responding, assured them that both he and his son were extremely gratified to find that the members of the Branch had so greatly enjoyed their visit. He wished to include their staff as well, and particularly their foreman moulder, without whose efforts they could not have attained their present state of perfection in turning out the shells. (Applause.)

Mr. Hogg said he owed his personal thanks to Mr. Chadwick for the very kind manner in which he received the first suggestion that the Branch should visit the works, and the prompt and hearty way in which he extended the invitation, and promised to do what he could to make their visit profitable and instructive. He was sure everyone present would agree that he had more than fulfilled his promise. (Applause.) He was greatly obliged to Mr. Hill for the hint he had given them regarding the formation of a special committee for organising propaganda work, and he could assure him it would be taken into very serious consideration without loss of time.

NEWCASTLE BRANCH.

At a meeting of the Newcastle and District Branch of the British Foundrymen's Association on October 27, a Paper on "The Modern Development of Moulding Machines" was read by Mr. R. Carrick, of Shipley, Yorkshire. The President of the Branch, Mr. W. Mathews, was in the chair. The Paper was published *in extenso* in our issue of June last.

An interesting discussion followed, in which the President, Mr. Patterson, Mr. Ireland, Mr. J. Smith, Mr. Davison, Mr. Readhead, and others took part, and Mr. Carrick was cordially thanked for his instructive and informative Paper.

SCOTTISH BRANCH.

At a meeting of the Scottish Branch of the British Foundrymen's Association, held at Glasgow on November 17, Mr. Matthew Riddell in the chair, Mr. A. Weddell lectured on "Electric Cranes." He stated at the outset that the application of electricity to crane work was of comparatively recent date, and did not go further back than about twenty years. Since that time, however, the progress which electricity had made in this particular direction had been very rapid. Mr. Weddell then traced the development of the electric crane from its infancy to its present high state of efficiency. The first application of electricity to cranes was to clutches and gearing of existing cranes, this proved such a success that its its general application was almost immediate.

The lecturer then compared the advantages which the electric crane possessed over the older methods of hoisting by steam and hydraulic power. The disadvantage of steam was chiefly because of the fact that the pressure of the steam had to be maintained during the intervals in which the crane was inactive. With the hydraulic system the same power had to be used irrespective of the load. In nearly every respect the advantages were in favour of electricity, and in many respects the electric crane was more suitable for the requirements of the foundryman than either of the older types mentioned.

SHEFFIELD BRANCH.

At a meeting of the Sheffield Branch on November 16, Mr. John Little in the chair, PROFESSOR THOMAS TURNER, M.Sc., A.R.S.M., of Birmingham University, delivered a lecture, illustrated with lantern slides and blackboard diagrams, on "The Use of Graphics in Metallurgy." It was a very interesting discourse on the meaning and value of the diagrams which are used in scientific literature to record elongation, melting points, and many other matters. Beginning with a simple illustration of a man piling bricks up, and showing how a curve could be drawn to indicate at a glance his rate of progress, he pointed out that many things could be represented by a straight line—among them the pressure of a gas, the effect of heat upon a gas in expanding it, the rate of volatility of a metal, the expansion of metals by heat, and the electromotive force of metals. A practical instance was a diagram to show the hardness of a piece of metal. Supposing he wanted to know how hard a piece of cast iron was, he took a drill and made it work at a uniform rate; then, by combining the speed of the drill and the depth that it cut into the cast iron, he got a diagram. He exhibited a curve showing the rate of volatilisation of zinc with different atmospheric pressures, and one illustrating what happened when a piece of wrought iron was heated up to a temperature of 700 deg. or thereabouts and then cooled, showing temperature and increase of length.

There were a great many things that could not be represented by a straight line, but could be represented by other curves. Sometimes these curves could be deduced mathematically, but sometimes they could not be so deduced but could only be observed. One of the simplest examples of a non-regular curve was a cooling curve. When cooling any metal at some time there would be got an arrest point, but one could not calculate where that arrest would come. It had to be observed. Among the curves with which he illustrated this part of his lecture were some showing the curious effect of adding an impurity, such as arsenic, to copper, diminishing the conductivity of the latter. He said many people had been trying to make a better conductor than copper or silver, but it was impossible. They could not make a better conductor than a pure metal. If they took any pure metal and added any other metal to it, it became a worse conductor. He went on to explain the more complicated kinds of curves, illustrating three and four variables, and involving the use of the equilateral triangle and the tetrahedon.

DR. HATFIELD, referring to the lecturer's point that 1 per cent. of arsenic decreased the electrical conductivity of copper to 75 per cent., asked if he had any data showing the effect of the same amount of arsenic upon the thermal conductivity.

PROFESSOR TURNER said he had not. Electrical conductivity had been so much more easy to determine, and had been done by so many more people, relatively, but thermal conductivity had not been investigated to the same extent. It was a matter that needed to be taken in hand.

DR. HATFIELD said the idea had been prevalent that electrical conductivity was a fair indication of thermal conductivity, but he thought that was now established to be not the case.

LONDON BRANCH.

Presidential Address.

At the first meeting of the session of the London Branch of the British Foundrymen's Association, Mr. T. W. Aitken (Luton) delivered the following brief address:—

Although the opening of the new session of this Association is at a time when men and women are chiefly occupied in the manufacture of implements of destruction, we realise that the end of this conflict is rapidly approaching, and it behoves foundrymen to be ready for a commercial business that no doubt will be, for a period, keener than ever it was before. In order that we may maintain the position of the foundry trade, we must unite and master a larger percentage of the many problems that still stand before us.

It is regretful to have to state that the large majority of foundry workers, chiefly moulders, commence each subsequent week or year without being any wiser for the struggles of the previous week or year; and, what is still more regretful, they do not care so long as they have had regular employment and can earn a living wage. Passing through any of our best foundries one can note the several moulders working at their respective jobs, and the casual observer might feel satisfied that everything appears to move along smoothly, suggesting a complete mastery over all the complex and intricate problems that are known to be solved in the construction of the several moulds. On making inquiries we discover that the present success is only the result of repeated trials in the past, all of which have been very costly; but among such a shop of moulders there can be found one or more who can see the end from the beginning, who pursue an intelligent course throughout the whole process of forming their moulds and are able to give a reason for every move they make. Such men are the backbone of the foundry trade. For a man to attain such a mastery over his trade he must have a scientific education; not that it is necessary for him to have taken his degree in metallurgy or chemistry, but he must have a good knowledge of mathematics and chemistry of metals, coupled with a reasonable experience of shop practice in which he can apply his scientific knowledge.

It is often stated as an excuse for not having the

necessary scientific education that no opportunities were presented to him, or that he was the son of humble parents who could not afford to allow him the necessary time to study; but this should not be accepted as an excuse, for in every district now evening technical classes are provided, and it matters not what age this particular unfortunate individual is, he will receive a very cordial and respectful welcome as a student. Further, many a man will state as an excuse for not attending such classes that he has worked sufficient hours for one day when he has completed his day's work. What a mistake this man is making! He will find that attention to studying the scientific side of his trade is not work, but a very pleasant recreation which will have a remarkably inspiring effect upon his mind. He will feel that his daily occupation is becoming less monotonous, and he is physically and mentally stronger, so much so that he will be wishing the British Foundrymen's Association had meetings more often, and that more difficult work could be entrusted to him so that he might exercise his full knowledge of his trade.

There are many questions which must claim the attention of the moulder. Taking one—the functions of runners and down gates—it must be remembered that these are not only provided for filling the mould, but must serve the purpose of preventing castings from being blown or drawn; also the depth of gate plays an important part in the solidity of the casting; further, a gate may be larger than is necessary, and involve a waste of good molten metal to fill same. The latter is a point which must claim the attention of our foremen, as no firm can afford to melt metal for this purpose. Again, it is sometimes necessary for the runner to be lengthy and at other times short. The position also of the runner will often mean the difference between a strong casting and a weak one, owing to the effect it has upon the solidifying of the metal in the mould and the regular contraction throughout the casting which is always desired.

The question of moulding sand is very important. Members of this Association have had the assistance of our chemists in this matter, but without the practical knowledge of those who have studied the results of the many qualities that may be obtained, and ascertained for themselves the exact cause of results obtained, we have made no advance. It must be remembered that water itself is not a binder of sand, but only converts certain substances in the sand to be binders. It is well known amongst foundrymen that different classes of work require different kinds of sand, and the chief consideration to have in mind is whether the sand is sufficiently porous for the particular volume or body of molten metal to force the gases and steam through without being overcome by the resistance of these gases or steam.

Even when suitable sand is supplied to some moulders for their particular jobs, often they are at a loss as to how hard to ram it; hence we may have blown, scabbed or misrun castings resulting, or, on the other hand, those which have gained through the mould being too soft.

This question of wasters is a most serious matter with every foundryman, and is the cause of greatly increasing the cost of production, therefore it must claim the earnest attention of this Association if we are to be the national asset that we claim to be.

The melting of metal, too, must have the closest attention of our members. It is possible to find one furnaceman getting a good metal and another a bad or poor metal from the same materials; and, again, one may melt cast iron with less than two cwt. of coks per ton of metal, whilst another cannot get the same metal melted so well with 2½ or 3 cwt. per ton.

All these foregoing points have received the attention of this Association from time to time, and it is to be hoped that we may find our country becoming stronger and stronger through the efforts of the British Foundrymen's Association, with its practical assistance to the foundry trade.

Metal Dealers and the Ministry.

The annual meeting of the Midland Metal Dealers' Association, the membership of which comprises representatives of the trade in all parts of the kingdom, was held in Birmingham on Thursday, November 8. Mr. Hedger Edwards presided.

Dealing with the correspondence with the Ministry of Munitions, Mr. Mousir (Hon. Secretary) stated that in a letter dated January 26, 1917, the Ministry informed him, with regard to copper, that there was no objection whatever to members purchasing scrap copper in the ordinary way of business, and that they might also pass the copper on to the larger merchants, who would accumulate the metal in sufficient quantities to meet the Ministry's requirements. In a letter dated May 5, the Ministry informed him that every quantity of scrap copper, large or small, must be reported. In reply to an inquiry as to lead, a letter dated February 15 stated: "Your members who are metal dealers accustomed to buy lead scrap should apply here individually for a licence to continue this class of business. There is every desire to enable dealers to continue their business as hitherto so long as they conform to the recently issued Order." As this reply was an awkward matter for a number of members, he arranged a deputation to the Ministry, with the result that Col. Foster gave permission as a whole to the Association to buy scrap lead, and subsequently a general licence was issued confirming this. At their interview they put it to Col. Foster that if they were short of lead and were wanting scrap metal the old law preventing a man from buying quantities under 112 lbs. should be abolished, so that people could be appealed to from motives of patriotism to bring up their little quantities of lead. Susequently Col. Foster wrote saying that he had consulted the Home Office, who definitely refused to entertain the suggestion, which had already been put forward unsuccessfully with regard to brass and copper. Then came the abolition by the Ministry of Munitions of various Orders, with the result that lead was placed on the same footing as copper. When zinc became a controlled metal he wrote to the Ministry asking for permission for the members to deal in zinc in the same way as they had dealt in lead. On April 10 he received the desired authorisation for the members to continue to purchase all forms of scrap goods as heretofore, on the understanding that when the spelter was resold it should be disposed of only to such firms as had a licence or letter of authority from the Ministry to purchase. As the result of further correspondence he got the members out of the difficulty of having to make a return of their zinc each month. Several of the members wrote to say that they were breaking up derelict motor-cars to get their aluminium contents, and that permits were wanted. As the result of correspondence in August, he succeeded in getting a considerable number of permits for members for this purpose.

On Mondays, December 3, 10, and 17 a course of three lectures on "Progress in the Metallurgy of Copper" will be given before the Royal Society of Arts by Dr. H. C. H. Carpenter, Professor of Metallurgy, at the Imperial College of Science.

A West-Country Foundry.

An interesting booklet of information for their employés has been issued by Petters, Ltd., engineers, of Yeovil. The idea is to give the employés a survey of the growth of the firm and the business carried on at the various branches, also the names of the directors and managers. In a large establishment it is not always easy for the employés to obtain this kind of information about the firm for which they are working, and it is the firm's opinion that a "house organ" to its own employés is a most useful book.

The works owned by the concern are the Petter Stationary and Marine Oil Engine Works, Westland Aircraft Works, Westland Iron and Steel Foundry, and Westland Plough Works.

In the very early days of the war the directors of the company offered their manufacturing capacity to the Government for the purpose of making munitions of war, or otherwise as required. As a result the company has been instrumental in delivering large quantities of war materials to the Government, and, in fact, the whole resources of the business, including the willing aid of its employés, have been directed to this end, and this, notwithstanding that since the outbreak of war, no less than 242 of the company's employés have temporarily left for definite military service of one kind or another. The present number of employés on the pay roll is:—Men and boys, 1,078; women, 322.

The Westland Iron and Steel Foundry, with which our readers are more concerned, is a new factory, completed just prior to the outbreak of the war, and consists of a block of buildings, in the design of which particular attention has been paid to lighting and ventilation, and to securing healthy conditions of employment for the foundry employés. The primary object in building Westland Foundry was to furnish the engine works with all castings necessary for the company's oil-engine business. In the early days of the war, however, it became evident that there would be a great shortage of munitions, and with a view to remedying this to the best of their ability, the directors decided that the foundry, in common with other branches of their business, should produce castings for outside customers, for war work, and particularly for the class of work which engineering firms found some difficulty in obtaining, namely, high class castings of an intricate and difficult nature.

Early in July, 1916, a new era was entered on in connection with the foundry, and one which promises important developments, viz., the manufacture of mild-steel castings. The progress which has been made in this direction, up to the present time, is highly satisfactory. It is more so owing to the fact that the patented method of production employed is an entirely new and original one, comprising a special plant for the manufacture of low-carbon crucible-steel castings, suitable for the motor and engineering trades. The castings are claimed to be of a homogeneous texture and require no annealing; consequently, there is no risk of warping or distortion. Moreover, by virtue of the method of manufacture, very prompt deliveries can be given, urgent or breakdown jobs having been despatched the same day as the patterns are received. The castings are mild steel throughout, which is a fact of great importance to machinists.

The booklet above mentioned describes the work of the other factories and also gives particulars of the social and welfare work. A welfare superintendent is employed, who visits the works daily and to whom applications can be made by employés requiring housing accommodation, lodgings, or other information or advice. The social side includes a men's social club, under the management of a committee of the members, a women's recreation club, under the management of a committee of the members and an advisory committee of ladies, and a technical and scientific library, the membership of which is free to all employés.

During the winter classes are held in machine drawing, applied mechanics and other engineering subjects, at the Yeovil School of Science and Technology. Facilities are given for learners in the works to attend these classes, and the fees are returned to all those students who make the required number of attendances.

Before the war there were flourishing football, cricket, and athletic sports clubs connected with the works. These activities are much restricted at present, but every encouragement will be given to resume them as soon as circumstances permit.

An ambulance is kept at the works, and first aid is given by trained officials. Workmen are cautioned to have slight injuries dressed and sterilised at once in the first aid department and not to attend to each other in the workshops.

IMPROVEMENTS IN THE REFINING OF IRON.—Mr. Arthur Rollason, metallurgist, of Station Street, Nottingham, has been granted patent rights for an improved process for refining iron made from phosphorus or common pig-iron, the object of the invention being the production of an iron suitable for the manufacture of the highest grade of steel. In his process, it is proposed to carry out the refining in separate stages, and in such a manner as to remove a large portion of the impurities from the metal before it reaches the final refining stage, thus reducing the work in the electric furnace, and carrying out the operations under complete control and much more rapidly and effectively, with less wear and tear on the furnaces, and at a reduced cost. The inventor claims for his process the possibility of using pig-iron, the composition of which may be of wide limits, high in silicon and phosphorus, and with a sulphur content of 0.2 per cent. or less. The first stage consists of the desiliconisation and decarbonisation of the metal, for which purpose sufficient molten metal from the blast furnace or cupola is teemed into an ordinary acid-lined converter (preferably of the side-blown type) with surface oxidation, and is blown in a manner similar to that used in the Tropenas process. In the second stage the dephosphorisation and desulphurisation take place, for which purpose the molten metal is transferred from the first converter to a second converter of the side-blown type with surface oxidation, but constructed with an extra set of tuyeres. This second converter is lined with a basic material, and with the addition of the necessary lime is blown as a basic blow. If the phosphorus content of the metal is low it is proposed to blow air and gas through the extra tuyeres, and through or over the metal to raise its temperature. If overblown, it is proposed to blow air through the tuyeres over the metal to lower its temperature. The third stage consists in the deoxidation and complete refining. The molten metal from the second converter is now transferred to an electric furnace heated ready for the charge. To prevent oxidation, the highly silicious slag from the acid-lined converter, together with any other necessary material, is added to the furnace either before or after the transfer of the metal. A low-voltage alternating current is used to keep the metal hot and in circulation, which action brings into intimate contact the whole of the molten metal with the elements and slag added, and complete deoxidation and the elimination of the remaining impurities in the metal is effected thereby.

Engineering Training.

At a meeting of the Institution of Civil Engineers, held at Westminster on October 25, a proposal to establish a central organisation for improvement in, and better co-ordination of, Engineering Training, and to appoint a representative committee of engineering and educational interests to initiate action, was considered. The chair was taken by Sir Maurice Fitzmaurice, C.M.G. (President).

The following resolution was moved by Sir John Wolfe-Barry, K.C.B. (Past President), and seconded by Dr. W. H. Hadow, M.A. (Principal of Armstrong College, Newcastle-on-Tyne):—

"That this meeting of engineers and educationalists is of the opinion that a need exists for improvement in and better co-ordination of engineering training, and considers that some form of central organisation is a desirable means to this end. It is therefore resolved that a representative committee, with powers to add to their numbers, be appointed to initiate means that will give effect to this principle of a central organisation, and that the first members shall be representative of the following bodies:—Institution of Civil Engineers, Institution of Electrical Engineers, Institution of Mechanical Engineers, Institute of Naval Architects, Iron and Steel Institute, Liverpool Engineering Society, South Wales Institute of Engineers, Institution of Civil Engineers of Ireland, Institute of Metals, Institution of Municipal and County Engineers, Institution of Gas Engineers, Institution of Mining Engineers, Institution of Mining and Metallurgy, the Technical Committee of the Motor Industry, the Federation of British Industries, the British Engineers' Association, the Board of Education, the Headmasters' Conference, the Incorporated Association of Headmasters, the Association of Technical Institutes, Junior Institution of Engineers, North-East Coast Institution of Engineers and Shipbuilders, Institution of Engineers and Shipbuilders in Scotland, the British Electrical and Allied Manufacturers' Association, the Universities and Technical Colleges of University rank, the Joint Committee of the Aeronautical Society and Society of British Aircraft Constructors."

In a memorandum outlining the origin of the proposal, Mr. A. E. Berriman (chief engineer of the Daimler Co., Coventry) explained how it originated in an informal conference of engineers and educationists, which held several meetings at the Board of Education during the early months of 1917. The conference presented to the Board of Education a memorandum embodying the suggestion that a bureau might be established within the Department. At the wish of the Board, the suggestion was communicated to as wide a circle of engineers and educationists as possible, and elicited strong support. A marked feature of this support, however, was an expression of opinion on the part of many engineers that it would be preferable to establish the proposed organisation on an independent footing, so that while co-operating closely with the Board of Education and other educational bodies, it might be free from the need of Government finance. Mr. Fisher (President of the Board of Education) concurred warmly with this view, and his Department has taken a very close interest in the initial steps of its development. Inasmuch as the broad purpose of the proposed organisation is to provide the engineering industry and profession with a representative brain and articulate voice on educational matters, it is obvious that any such scheme essentially depends on the combined assistance of the various institutions. Primarily it will co-ordinate things that exist, for although it must exert a live and progressive influence, it is in no sense intended to be competitive with institutions that have already done and are still doing most useful work in their individual spheres. Rather will it endeavour to bring them together in conference so as to avoid overlapping of effort.

There are three objects in particular on which the proposed central organisation might usefully concentrate its attention: (1) The co-ordination of engineering training, including the fostering of apprenticeship as a national institution, and the consideration of means by which the works period of an engineering pupilage may be increased in efficiency, and a wider appreciation secured for the value in industry of education of university rank. (2) The maintenance of a central bureau, where parents and educationists can obtain accurate and comprehensive information relating to the engineering industry, and the proper course to pursue on behalf of boys who are desirous of making engineering their profession. (3) The promotion of scholarships or other equivalent means by which the best talent may be enabled to rise to its proper level under the stimulus of educational opportunity. With regard to the first of these objects, co-ordination refers primarily to encouraging a proper relationship between school work and shop work for all classes of engineering students. Incidentally there is a widely recognised need for encouraging lads to become apprentices as distinct from mere members of the vast community of child labour, and this recognition extends also to the need for effecting improvement in the educational value of the works period of engineering training. The significance of the works period in an engineering training cannot be too strongly emphasised, for not only are the shops the natural nursery of the majority of the charge hands, foremen, and superintendents, on whose efficacy and efficiency so much of our engineering economy depends, but there is an immensely important section of higher engineering education for which the productive works, or the equivalent civil engineering enterprise, is an indispensable class-room. And in this respect it is important to make clear that the scope of the proposed central organisation has not been restricted to the field of engineering science. The work of the technologist is the foundation on which the engineering industry, in the broader sense of the term, develops, but the problems of economic production, as they appear to the works manager, and, in the higher aspects of business, to the director of engineering commerce, must equally receive attention.

The need for making the most of those who do enter engineering is equally vital and leads logically to the inclusion of the third of the above-mentioned objects of the organisation. Without doubt, much potential talent is prevented from developing either as quickly or as widely as it could through lack of financial assistance, and it would be a worthy endeavour on the part of the engineering world to attempt some improvement in this direction by fostering the establishment of proper scholarships. This interest of the proposed organisation would not be restricted to any one class of engineering student; indeed, it would inevitably become one of the main supports of a new "educational ladder," which many hope to see extend from the bench to the university for those boys, irrespective of social distinction who are able to climb thus high.

Personal.

THE late Mr. A. P. Townshend, iron and steel merchant, Birmingham, left £14,000.

MR. H. BIRTLES has been appointed Registrar of Companies for England and Wales.

MR. A. A. LAWSON has retired from Messrs. Lawrie & Lawson, iron merchants, Edinburgh.

THE gross value of the estate of the late Mr. H. Ritchie, shipbuilder, of Partick, is £9,460.

MR. J. WHITESIDE, of Giffnock, Glasgow, has been appointed an Inspector of Factories and Workshops.

ESTATE of the value of £32,114 has been left by the late Mr. T. Mitchell, iron and tool merchant, Bolton.

MR. D. DAWNAY, of Archibald D. Dawnay & Sons, Limited, Battersea, S.W., has been re-elected Mayor of Wandsworth.

SIR DAVID SHACKLETON, secretary to the Ministry of Labour, has appointed Mr. W. G. Eady to be his private secretary.

ESTATE of the gross value of £64,389 has been left by the late Mr. C. R. Murray, iron merchant, Woodbank, Partickhill.

THE late Mr. A. S. Biggart, of the Dalmarnock Iron Works, Bridgetown, Glasgow, left personal estate value at £47,778.

THE late Mr. C. E. Atkinson, J.P., a director of Fraser & Chalmers, Limited, left estate of the gross value of £113,605.

THE late Mr. Morton Muir, iron, steel and chemical merchant, of Glasgow, has left estate of the value of £11,485 gross.

PERSONAL estate of the value of £8,973 has been left by the late Mr. H. Ritchie, shipbuilder, of Partick, Glasgow.

CAPTAIN J. D. WHITE, of the London staff of the James Keith and Blackman Company, Limited, has been awarded the D.S.O.

THE Right Honourable Lord Carmichael has accepted a seat on the Board of the British Thomson-Houston Company, Limited.

THE MINISTER OF RECONSTRUCTION has appointed Mr. Vaughan Nash and Mr. G. M. Young to be joint secretaries to the Ministry.

THE value of the personal estate of the late Mr. A. S. Biggart, chairman of Sir William Arrol & Company, Limited, is £47,778.

ESTATE of the gross value of £1,523 has been left by the late Mr. F. S. Raby, one of the guarantee engineers with Vickers, Limited.

THE late Mr. C. Gill, of Gill & Russell, Limited, Cyclops Tube Works, Walsall, left estate of the value of £199,740, with net personalty £198,060.

ESTATE of the gross value of £10,807, with net personalty £1,604, has been left by the late Mr. J. S. C. Watson, shipbuilder, of Beckingham, Notts.

THE late Mr. J. I. Jacobs, chairman of the Queenstown Dry Docks, Shipbuilding and Engineering Company, Limited, has left estate of the value of £841,645 gross.

THE late Professor Charles Latham, Professor of Mining Engineering, late of the University, Glasgow, left personal estate in the United Kingdom valued at £3,018.

The Ministry of Munitions has appointed Lieutenant-Colonel A. G. Stern, C.M.G., to be Commissioner of the Mechanical Warfare (Overseas and Allies) Department.

MAJOR HENRY NEWTON, D.S.O., a member of the firm of Newton Brothers, (Derby), Limited, electrical engineers, of Derby, has been appointed Assistant Director of Trench Warfare.

SEC.-LIEUT. R. J. KEATES, R.G.A., who has been awarded the M.C., was, previous to the war, London manager to John Webb & Company, Limited, Crescent Works, Hockley, Birmingham.

MR. G. RYDER, J.P., has been appointed to sit upon the Special Arbitration Tribunal set up under the Munitions of War Act. He was the Midland delegate of the Amalgamated Society of Engineers.

MR. C. JONES, for many years manager and secretary of J. Grayson Lowood & Company, Limited, silica brick manufacturers, Deepcar, near Sheffield, has been elected a director of the company.

THE HON. EDWARD WOOD, M.P., has been appointed assistant secretary in the Ministry of National Service, to act as Chief Liaison Officer between the Ministry and other Government Departments.

THE late Mr. H. Dennis, founder of the firm of J. H. Dennis & Company, Limited, Liverpool and Widnes, copper smelters and sulphate of copper manufacturers, left estate of the gross value of £655,924.

LIEUTENANT J. S. WESSON, Worcestershire Regiment, attached Royal Flying Corps, son of Mr. W. Wesson, of the Victoria Iron and Steel Works, Moxley, near Wednesbury, is officially reported wounded for the second time.

MR. A. GAVIN, managing director of the Dalmellington Iron Company, Limited, has been the recipient of a presentation from the officials, men and shareholders in recognition of his having completed 65 years in the service of the company.

MR. E. B. WINN has resigned his position as chairman and director of Webley & Scott, Limited. The directors have elected Mr. T. W. Horton to be a director of the company, and he will also occupy the position of chairman.

OWING to ill-health, Mr. W. B. Worthington has been compelled to resign his position as engineer-in-chief of the Midland Railway Company. Mr. J. Briggs, the assistant engineer, has been appointed to succeed Mr. Worthington.

MR. J. HOLEY, who has retired from the secretaryship of Wm. Doxford & Sons, Limited, Sunderland, at the age of 75 years, after having served the firm for 48 years, has been the recipient of a presentation from the officials and staff.

DR. JOHN CADMAN, Professor of Mining at the University of Birmingham, and technical adviser to the Government on questions affecting petroleum oils and products, has had the Legion of Honour conferred upon him by the French President.

MR. W. J. REES, chief chemist to Chance Brothers & Company, Limited, and a past-president of the Birmingham Section of the Society of Chemical Industry, has received an appointment as head of a new department at Sheffield for research work on refractories for furnace linings.

MR. J. E. DOBSON, late Scottish representative of Bruce Peebles & Company, Limited, has been appointed London office manager to the company in place of the late Mr. R. W. Gauntlett, and has now taken up his new duties at Hastings House, Norfolk Street, Strand, W.C.2.

MR. R. E. ELLACOTT, who for the past four years has been works manager of the Mining Engineering Company, Limited, Meco Works, Moorfields, Sheffield, has been the recipient of a presentation from the officials and men on the occasion of his leaving the firm to take up another appointment.

THE MINISTER OF MUNITIONS has made the following appointments:—Mr. W. T. Layton, to be an additional member of the Munitions Council for Requirements and Statistics; Mr. Alexander Walker, to be Controller of Salvage and Stores; Major R. O. Dodgson and Captain Ivor Rose, to be Assistant Directors in the Trench Warfare Department.

AT a social gathering of managers, foremen, and employés of Ferranti, Limited, Mr. R. J. Shaw was the recipient of a presentation on the occasion of his leaving his position at the works at Hollinwood, Manchester, after fifteen years' service (ten years as foundry manager), to take up a similar position with the United Brassfounders and Engineers, Empress Foundry, Cornbrook, Manchester.

MR. L. JONES, who has been for a considerable time at the Priority Department of the Ministry of Munitions, has been appointed secretary to the South Wales Siemens Steel Association. He succeeds Mr. F. J. Rees, who for several years has been the honorary secretary of the association, and has resigned in consequence of the increase of the work necessitating the appointment of a paid secretary.

Mr. R. H. Hughes has been re-elected president of the North-Eastern Association of Iron and Steel Merchants, which has its headquarters at Middlesbrough. Mr. J. A. Thomas has been re-chosen as vice-president, Mr. C. J. Sambidge as hon. treasurer, and Mr. T. Brown as hon. secretary. The committee appointed consists of Messrs. J. D. White, P. Roberts, J. W. Brown, R. R. King (Garston), W. A. Bainbridge, W. T. Thomson, D. Watson, and C. A. Hill (Hull).

The King has granted authority to Sir John Hunter, K.B.E., Director of Factory Construction and Director of Iron and Steel Production, Sir Leonard Wilkinson Llewelyn, K.B.E., Controller of Non-Ferrous Materials Supply, and Mr. William Turner MacLellan, Officials of the Ministry of Munitions of War, to wear the Cross of Chevalier of the Legion of Honour, which decoration has been conferred upon them by the President of the French Republic in recognition of valuable services rendered by them. It is also announced that Col. Charles Wright has had a similar honour conferred upon him.

Sir Boverton Redwood, Bart., Director of Petroleum Research, who has been adviser on petroleum to the various Departments of the Government for many years, has been appointed by Mr. Walter Long, Director of Technical Investigations in the recently created Petroleum Executive, with a view to his dealing with technical questions of the highest importance, including the co-ordination of the work of petroleum production and that of petroleum research. In order to devote himself to his new duties Sir Boverton Redwood will cease to act as Director of Petroleum Research.

Deaths.

Mr. A. H. Pegler, of the Weardale Lead Company, Limited, died on November 14.

Mr. T. D. Merton, the inventor of the Merton furnace, died recently at the age of 63 years.

Mr. J. Meredith, of Messrs. J. Meredith & Company, engineers and ironfounders, Kington, died recently at the age of 77 years.

The death is reported of Mr. W. Wedlake, ironfounder, of the White House, Hornchurch, at the age of 88 years.

Capt. H. Kekewich, of Messrs. Morrison, Kekewich & Company, metal merchants and brokers, has been killed in action.

Mr. W. N. Baines, of Messrs. W. N. Baines & Company, brassfounders, of Rotherham, and a director of Potters, Limited, died recently.

The death took place recently of Mr. R. F. Andrew, of Messrs. Holgate & Fishwick, engineers, etc., Liverpool and Bury, at the age of 76 years.

The death has occurred, at the age of 54 years, of Mr. G. T. Holloway, of Messrs. G. T. Holloway & Company, consulting metallurgists, &c., of Limehouse, London, E.

Sec.-Lieut. C. O. Boswell, East Lancashire Regiment, who was killed in action on the 9th ult., was, previous to the war, manager of the Liverpool branch of H. Pooley & Son, Limited.

Sec.-Lieut. E. B. Butler, R.F.A., killed in action, was the son of Mr. H. B. Butler, chairman of Charles Joyner & Company, Limited, Birmingham, and a director of Butlers, Limited, Small Heath.

Major M. Hodgart, Royal Engineers (killed), was the son of the late Mr. John Hodgart, Lumsburn, Paisley. He was a director of Fullerton, Hodgart & Barclay, Limited, engineers and ironfounders, Paisley.

The death was announced at Hull on November 1 of Mr. A. Cochrane, head of the firm of Cochrane & Sons, Limited, shipbuilders, of Selby, widely known in connection with the construction of steam trawlers. He was 77 years old.

The death took place on November 3, as the result of an accident, of Mr. James M. Oliver, of Liberton House, Midlothian, at the age of 53 years. The deceased gentleman was a director of James Milne & Son, Ltd., engineers, Milton House Works, Edinburgh.

Lieut.-Col. R. A. Hudson, D.S.O., commanding a battalion of the West Yorkshire Regiment, who was reported wounded for the second time in our last issue, is now reported killed in action. He was one of the managing directors of Robert Hudson, Limited, Gildersome Foundry, Leeds.

The death took place last month, after a brief illness, of Mr. John Cochrane, Barrhead. Mr. Cochrane was a well-known man in the engineering world, and in partnership with his brothers carried on the business of Grahamston Foundry, established at Barrhead many years ago by his late father.

Second Lieutenant H. Procter, R.E., who is officially announced to have died on November 11, from accidental injuries, was the only son of Mr. Procter, of Cloughton, near Scarborough. Prior to joining the Forces he was employed on the engineering staff of the British Thomson-Houston Company.

Lieutenant H. S. Manisty, M.C., R.E., killed in action, was the son of the late Mr. E. Manisty, M.I.C.E., M.I.M.E., and was an A.M.I.C.E. and A.M.I.M.E. As assistant engineer to Messrs. Price & Reeves and Messrs. C. H. Walker & Co., he was associated with many important undertakings.

Sec.-Lieut. L. P. Sidney, K.R.R.C., attached R.F.C., was reported missing on October 2, and has since been reported killed, aged 24. He was a son of Mr. L. P. Sydney, assistant secretary of the Iron and Steel Institute, and was in the service of Bell Brothers, Limited, Middlesbrough, as metallurgist, when the war broke out.

Mr. P. Denny, the well-known shipbuilder and engineer, died suddenly on November 19 at Dumbarton. He was one of the most popular men in Clyde shipbuilding circles, and was associated with his brother and his cousin in the direction of the famous firm of Messrs. Wm. Denny & Brothers, Dumbarton. Mr. Denny, who was 64 years of age, was the son of the late Mr. Peter Denny.

Mr. W. Du Bois Duddell, consulting engineer, died last month at his residence in Victoria Street, Westminster, London, S.W., at the age of 45 years. The son of the late Mr. G. Duddell, of Brighton, he was apprenticed with Messrs. Davey, Paxman & Company, of Colchester, and afterwards carried out research work in engineering and physics at the Central Technical College, London, for seven years, during which time he obtained a Whitworth exhibition and a Whitworth scholarship.

We regret to announce the death at Bournemouth, on November 2, of Mr. Isaac Butler, J.P., of Panteg, Mon., who was High Sheriff of the county in 1911. The deceased gentleman, who was 80 years of age, was one of the founders of the firm of Baldwins, Limited. He commenced to work at a very early age under his father, Mr. Jacob Butler, at Messrs. Thorneycroft & Company's Shrubbery Ironworks, at Wolverhampton. After serving with Messrs. Ashbury & Company, at their ironworks in Manchester, Mr. Butler had engagements with several well-known companies. He went to America in 1863 and became associated with the American steel industry. He returned to England and was engaged at Sheffield before he settled in South Wales, in 1869, to assist Dr. Siemens in the establishment of the first works for the manufacture of Siemens-Martin steel at Landore. These works and the Cwmavon Works, Port Talbot, were subsequently acquired by Mr. Butler, in conjunction with Colonel Wright, and in 1892 came the fusion of several companies into Baldwins, Limited. He retired from the directorship of Baldwins, Limited, five years ago. He was chairman of Cordes (Dos Works), Limited, Newport; Hill & Company, Limited, Cwmbran; and Morris & Griffin, Limited, besides being a director of other companies in the United Kingdom, South Africa, and Italy. His firm (Wright, Butler & Beck), which had extensive works at Swansea and Panteg, was one of those concerns which were amalgamated with Baldwins, Limited.

Trade Talk.

FASTNUT, LIMITED, have removed to 159/161, Great Portland Street, London, W.1.

R. & J. DEMPSTER, LTD., have removed their London offices to Connaught Mansions, Victoria Street, S.W.

A FIRE has occurred at the British Metal Works, Llansamlet, doing considerable damage to the offices.

MR. R. J. RICHARDSON has removed his works from Baskerville Place, Broad Street, to Commercial Street, Birmingham.

THE DUNSTON ZINC COMPANY, LIMITED, is being wound up voluntarily, with Mr. J. Buck, 30, Brown Street, Manchester, as liquidator.

THE CANADIAN GOVERNMENT has issued regulations regarding the price, sale, control, storage, distribution and transport of scrap iron and scrap steel.

FURNESS, WITHY & COMPANY, LIMITED, of West Hartlepool, have acquired the Rushbrooke Docks at Queenstown, from Messrs. Johnson & Perrott.

THE Iron and General Metal Trade Section of the Liverpool Chamber of Commerce has suggested the formation of a merchants' section of the Chamber.

Messrs. G. H. Walker and G. V. Deakin, engineers and merchants, Leeds, trading under the style of Gaskell, Walker & Deakin, have dissolved partnership.

A FIRE broke out at the Lochrin Iron Works, Coatbridge, owned by Wm. Bain & Company, Limited, considerable damage beng done to the oil and paint stores.

THE marine engineering works of Messrs. David Rowan & Company, Glasgow, have been acquired by Messrs. Russell & Company, shipbuilders, Port Glasgow.

MESSRS. A. J. FONTAINE, C. FONTAINE AND A. FONTAINE, brass, iron and lead founders, Newport, Mon.; trading under the style of A. J. Fontaine & Sons, have dissolved partnership.

BURYS & COMPANY, LIMITED, of Sheffield, for whom W. J. Bethell, Ltd., 46, Cannon Street, E.C., are the London agents, are making a speciality of bullet-proof steel for aircraft purposes.

A BLAST furnace at the Cyfarthfa Works, Merthyr, was started recently after a period of idleness extending over ten years. The works, it will be remembered, were partially reopened about twelve months ago.

CONSIDERABLE extensions are to be carried out at the shipbuilding yard and repairing works of Messrs. Scott & Sons, Bowling. The company propose to construct a tidal basin and a graving dock for medium-sized vessels.

THE partnership heretofore existing between Messrs. W. H. Hawkings and E. H. Bird, engineers, Burnham-on-Sea, trading under the style of the Somerset Engineering Company, has been dissolved. Mr. E. H. Bird will continue the business under the same style.

THE CHANNEL STEEL COMPANY, LIMITED, are reported to have selected a site near Dover for the blast furnaces which they intend to erect for dealing with the ironstone in the areas which they have acquired in East Kent, together with the Shakespeare Colliery.

WILLIAM FIRTH, LIMITED, iron and steel and machinery merchants, Leeds, have purchased the business of machinery and plant merchant conducted by the late Mr. John Conway, at the Royal Exchange Chambers, Leeds, with a view to amalgamating the same with their own machinery department.

THE SHELTON IRON, STEEL AND COAL COMPANY, LIMITED, have expressed their willingness to pay £100 towards a fund for research work in connection with refractory materials at the Central School of Science, Stoke-on-Trent. The sum of £1,500 is necessary to establish a department at the school.

A PRIVATE conference of persons interested in the tin and tungsten mines of Cornwall and Devon was held at the Ministry of Munitions on November 7 to consider the establishment of a research association and a central fund to be devoted to the study of the development of the industry. Sir Lionel Phillips presided.

MR. A. JOSEPH, of Earl Street, London Road, Southwark, London, S.E.1, informs us that he is unable to offer solder for the present. Having made an arrangement with the Director of Materials, Ministry of Munitions, for purchasing scrap metals on their behalf, Mr. Joseph has agreed to discontinue the manufacture of solder for the period of the war.

THE RENISHAW IRON COMPANY, LIMITED, have just completed alterations to a second furnace, which was lighted last month by Mr. T. Greensmith, one of the directors, and will be employed entirely on the manufacture of basic iron. The other furnace now in commission was blown in in March last, and is also on basic iron. Extensive alterations are being made to a third furnace.

AN interesting statement in regard to the new national shipyards was made by the Parliamentary Secretary to the Admiralty, in reply to a Portsmouth deputation last month. Dr. Macnamara said the Government were getting ready three national yards, but did not, so far as he could see, intend going on with the fourth at present. There was no intention of taking men away from existing Government yards for the new national yards.

THE EYRE SMELTING COMPANY, LIMITED, of the Barden Road Works, Tonbridge, have acquired the business and works of the Tandem Smelting Company, Limited, of Merton Abbey, London, S.W. In addition to their own specialities, the company will in future manufacture the -latter company's brands of anti-friction metals, etc., and carry on the assaying and metal refining business. The head offices are now at the Tandem Works, Merton Abbey.

THE British Industries Fair, to be held next year, for which application forms for exhibiting space are now being issued by the Board of Trade, will be considerably larger than those of previous years. The 1918 Fair, which will, as usual, open on the last Monday in February and remain open for a fortnight, is to be held in premises which the Port of London Authority have placed at the disposal of the Board of Trade. The Fair will, owing to the war, again be restricted to the trades selected on previous occasions.

In a reply to MR. G. LAMBERT, who asked whether all the private shipbuilding yards in the United Kingdom were fully equipped with labour and material for completing merchant ships to their utmost capacity, DR. MACNAMARA said that the private shipbuilding yards were not yet fully equipped with labour and material. Greatly increased quantities of material were being delivered in the shipyards; and the necessity for further labour now, and as the material increased, was engaging the attention of the Departments concerned.

IN delivering his presidential address on the subject of the gas industry to the members of the Institution of Civil Engineers, Mr. H. Jones said that Sir Robert Hadfield, at his Sheffield works, used 500 million cubic feet of gas per annum for smelting and metallurgical purposes. The Sheffield Gas Company had 642 furnaces, consuming 372 million cubic feet, while up to 789 million cubic feet was supplied to 15,116 h.p. in gas engines. From Birmingham, Manchester, Glasgow —indeed, from all the manufacturing towns—similar accounts were received.

THE NORTH OF IRELAND SHIPBUILDING COMPANY, LIMITED, are contemplating still further additions to their works at Londonderry. The firm are prepared to lay out the entire site facing the river at present included in their lease, if they obtain official sanction and certain facilities. In addition, the company have, we understand, as the result of negotiations in progress since the spring of 1916, recently acquired an area of approximately 56 acres, known as the Pennyburn Lands Estate, immediately behind the shipyard, which, it is understood, will be utilised for the extension of the engineering side of the business.

COLONEL FABER asked whether the President of the Board of Trade would break all contracts entered into

between the Board of Trade and H. Randall over the London Emery Works; and whether the Board of Trade had supplied this firm with contracts and raw material, and intended to continue to do so? Mr. Wardle said he was not prepared to make any statement with regard to the completion of the sale of the business of the London Emery Works to Mr. Randall pending inquiries which were being made. The Board of Trade had not given any contracts to that firm or supplied it with raw material.

In the course of an interview with a Press representative upon the position in South Wales in connection with the development of the manufacture of basic iron, Mr. J. Hutchinson, of the Cardiff Hematite Iron Ore Company, Limited, said it would not pay to utilise Welsh ores for the making of basic iron, and the cost of specially raising this ore would be prohibitive. At the present time the Landore furnaces were turning out basic iron from imported ore. Basic iron was also to be manufactured at Port Talbot in new furnaces now being erected there. It was also, he believed, being made at the re-opened Cyfarthfa Works, and at Ebbw Vale the manufacture of basic pig would likewise be started shortly.

In connection with the appeal for scrap metal for war purposes, the expected proportion of which from Scotland is 50,000 tons, emphasis was laid, at a meeting of Edinburgh Town Council, on the fact that iron and steel merchants throughout the country were in most urgent need of all kinds of scrap iron and metal for the production of new material for munitions and other war purposes. It was pointed out that a number of railings in public parks and elsewhere in the city might be pulled up and handed over, as they were neither ornamental nor useful. A committee has been appointed for Edinburgh, Leith and district, and a scheme for the collection of scrap metal is to be put into force without delay.

Nearly 10,000 workshops in Great Britain are now producing munitions of war. Of these 5,000 are establishments controlled by the Ministry of Munitions and 150 are national factories. The output of material of all kinds is on an immense scale, but the limit has not been reached. The erection of four new national factories, at a cost of over £2,000,000, has just been sanctioned, and extensions are being carried out in many areas. Existing workshops are being enlarged; a new factory is being built for the readaptation of old boxes and packing cases from the battlefields; aircraft and instructional factories are being established; and almost every week there are demands for other varieties of building subsidiary to the production of munitions.

The Principal of the Hull Technical College draws attention to the fact that the boilermakers of Earle's Shipbuilding and Engineering Company, Limited, have impressed upon apprentices the necessity of joining the evening classes at the College, and have undertaken to advance the fees and costs of books and materials to be repaid by instalments. As a result of this, one class of 35 boilermakers' apprentices has already been started. The principal believes this to be an almost unique case in engineering of an organisation of workmen distinctly bringing pressure to bear on the apprentices in that way. Further, the Boilermakers' Society have also been bringing strong pressure to bear on elder apprentices to join a special class in boilermakers' work at the college.

Subscriptions have been invited for 64,500 seven per cent. cumulative participating preference shares of £1 each in the London Foundry Company, Limited, which has a capital of £100,000, consisting of 89,500 £1 preference and 42,000 5s. ordinary shares. The prospectus states that the company's plant and works comprise a large steel foundry, in which is installed the most modern equipment, and that the production consists of steel and alloy steels of the highest class. The additional capital provided by the present issue is being used as further working capital and for building extensions to the works and foundry. In a letter dated June 8 last, Mr. J. S. P. Samborne, managing director of the company, says: "The additional plant and equipment should be completed in about six months, and should increase the output of electric steel castings from about 29 tons to about 60 tons per month, and the output of steel ingots from about 200 tons to about 600 tons per month."

The Board of Trade have now given formal sanction to a new company, with works in London and Liverpool, and known as the British Barimar-Thermit Welding Company, Limited, to take up and exploit the Thermit welding process which, prior to the war, was exclusively in German hands. It is the intention of Mr. C. W. Brett, the managing director and general manager of Barimar, Limited, scientific welding engineers, who is largely responsible for the formation and management of the company, to train disabled British soldiers and sailors to carry on the work. The registered offices of the new company are at 10, Poland Street, London, W.1. To prevent any misunderstanding we are requested to point out that the above company is in no way connected with Thermit, Limited, 675, Commercial Road, London, E.14, who are the owners of the Alumino-Thermic process patents, the new company merely holding a licence to work certain of the patents belonging to Thermit, Limited. Thermit, Limited, were originally established in 1904, and about eighteen months ago the whole of the shares were sold to the Birmingham Metal & Munitions Company, Limited.

Mr. W. L. Hichens, chairman of Cammell, Laird & Company, Limited, presided at the conference of Boy Welfare Supervisors at Munition Works, which concluded on October 26 at the Ministry of Munitions. Before the war, he said, the founding of a boy welfare department would have been treated with as much astonishment as if the Government had established a department of religion. It was intolerable that any employer should think that he had done his duty when he had paid his men their wages, and that he had no further responsibility or interest in them. There must be something beyond that cold economic chain which bound employer and workman together like prisoners. It was a sound thing that the Government should take a lead in welfare, but they must beware of grandmotherly interference. It would be a great mistake for employers to try and force themselves into the lives of the men whom they employed. "We must avoid smothering them with good intentions," said Mr. Hichens. "They must have a definite responsibility of their own, and we must not try and interfere with them in any way. We have to get them to welcome anything that we are doing for its own sake, and our trouble, it seems to me, will be to steer a clear course between the Scylla of indifference on the one hand, and the Charybdis of officiousness on the other." It was an essential part of welfare work that they should try to develop real education in the works.

Major H. Terrell asked the Minister of Munitions whether the Order dated July 7, 1916, fixing the maximum prices for pig-iron was intended to differentiate between pig-iron made within the geographical boundaries of Derbyshire, Leicestershire and Nottingham on the one hand, and that made within the geographical boundaries of Northamptonshire on the other hand, irrespective of the method of manufacture and quality of the pig-iron produced, or whether it was intended to differentiate between pig-iron manufactured by the methods generally adopted and of the quality generally produced in Derbyshire, Leicestershire and Nottingham on the one hand, and Northamptonshire on the other hand; and if the distinction was purely geographical and not dependent on the methods of manufacture or quality of the pig-iron manufactured, would he say why there was a difference in the maximum selling price between that made in Derbyshire, Leicestershire and Nottingham and that made in Northamptonshire? Sir W. Evans, replying to the question, said that the quality of pig-iron varies according to the district in which it is produced. The maxi-

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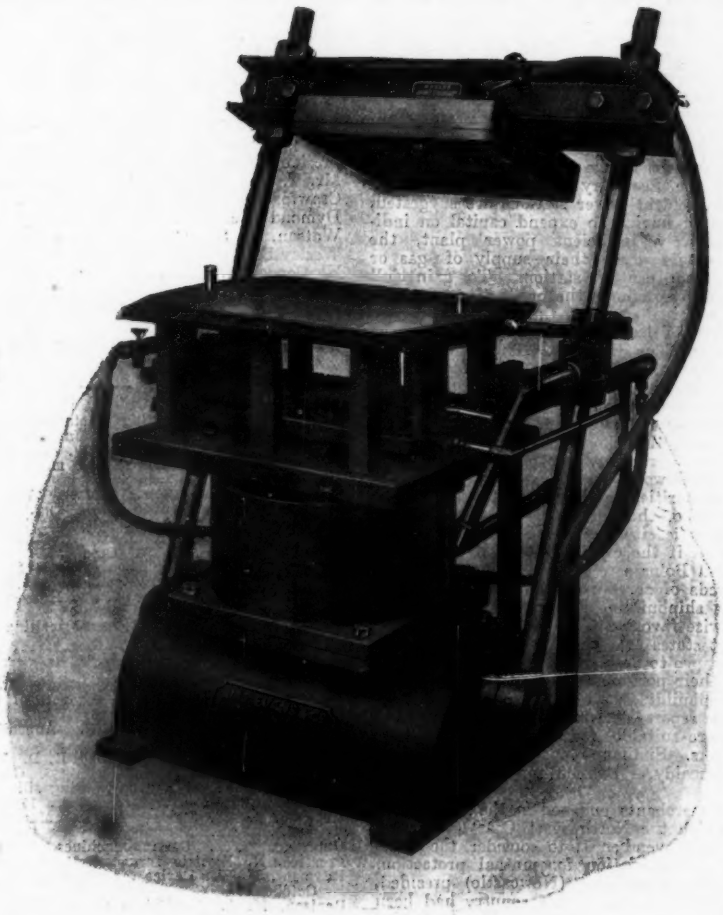

JAMES EVANS & CO., BRITANNIA WORKS,

BLACKFRIARS, MANCHESTER.

mum prices have been fixed at such levels as will give the manufacturers in each district a reasonable margin of profit. The difference between the maximum price for the Derbyshire, Leicestershire and Nottingham district, and the Northamptonshire district, is due to a difference in the average cost of manufacture. Further, Major Terrell asked the Minister of Munitions whether a manufacturer of pig-iron whose works were in Northamptonshire, but who manufactured pig-iron by the methods and of the materials used by manufacturers of pig-iron in Derbyshire and of the quality produced in Derbyshire, was entitled, under the Order to charge the rate fixed for Derbyshire pig-iron or those fixed for Northamptonshire pig-iron? Sir W. Evans: The manufacturers referred to will only be entitled to charge the rates fixed for the Northamptonshire district.

With a view to bringing under the notice of the Government the facilities for docking, shipbuilding, and ship-repairing at present existing at and adjacent to the various seaports on the Firth of Forth, conferences of the Provosts of the chief of these seaports were recently held at Leith. Reports from Leith, Bo'ness, Grangemouth, Alloa, Inverkeithing, Burntisland, Kinghorn, Kirkcaldy, Buckhaven, Methil, and Innerleven were submitted to the conferences, and these reports have been sent to the Admiralty, Ministry of Munitions, and the Secretary for Scotland. In the report on Leith, central power stations are suggested, so that, instead of having to expend capital on individual and relatively inefficient power plant, the various trades could draw their supply of gas or electric power from central stations. To gain full advantage of the by-products the production of power should be on a large scale at the coalfields, where there is a supply of low-grade fuel, which could be most readily treated on the spot. This would avoid the use of sites in and about the towns, which are of much greater value for industrial purposes, and largely do away with the smoke trouble. In the report from Bo'ness the shipping facilities are specified, and the statements are made that development must lie in the reclamation of the foreshores, on which might be provided sites for steel works and shipbuilding, and that the municipal authorities favour a Conservancy Board for the Firth west of the Forth Bridge. The Grangemouth report specifies its facilities and potentialities. It is "urged that if the extensive mud flats between Grangemouth and Bo'ness were reclaimed there would be many hundreds of acres available for works of all sorts, including shipbuilding yards." The municipal authorities likewise favour a Conservancy Board, while the Alloa report states that the siltage of mud in the Forth is a hindrance to development. The Inverkeithing people say their port offers very considerable possibilities for shipbuilding and dock construction, and the Burntisland report declares that there is much land and foreshore suitable for sites for shipbuilding and allied works. Similar reports are sent from Kinghorn, Kirkcaldy, Buckhaven, Methil, and Innerleven.

A MEETING of merchants engaged in the iron, steel, and metal trades on the North-Eeast Coast was held at Darlington, on November 1, to consider the question of forming an association for mutual protection. Colonel Sir Johnstone Wallace (Newcastle) presided, and said that the merchants of this country had been referred to as parasites on industry. He contended that their methods were strictly honourable. There was no intention of hindering the Government in the prosecution of the war, but the merchants claimed the right to carry on their business without undue and unnecessary control. Mr. J. Gray Buchanan, chairman of the Iron and Steel Merchants' Section of the London Chamber of Commerce, said the merchants had no objection to the Government controlling trade, but they objected to the way in which that control was exercised. The Government consulted the manufacturers, but ignored the merchants, whose knowledge and experience were invaluable. The manufacturers would have the labour problem on their hands after the war, and would have no time to cultivate new markets. There was a great danger that the confidential information which had been given freely to the Ministry of Munitions might be used afterwards to the detriment of the merchants. Mr. G. O. Wight (Sunderland) and Mr. R. M. Richardson (Newcastle) seconded a resolution, assuring the Government of their hearty co-operation in the prosecution of the war; but protesting against any unnecessary interference with legitimate business, and demanding the same consideration as is shown to manufacturers. It also warned the Government that any attempt to eliminate the merchant, and prevent him employing his capital, and carrying on his ordinary business after the war, would be attended with grave consequences to the community at large, besides proving a valuable asset to the enemy in his efforts to recapture trade in the world's markets. The resolution was carried unanimously. It was decided to form a local association of iron, steel, and metal merchants, and a committee was appointed to make arrangements. At a later meeting the rules were adopted as submitted, except that the entrance fee was fixed at £5 5s. instead of £10 10s. The officers were elected as follows:— President, Colonel Sir Johnstone Wallace; vice-president, Mr. R. T. Hughes, Middlesbrough; treasurer, Mr. T. Metcalfe, Newcastle; committee, Messrs. J. E. Crawford, R. M. Richardson, H. A. Lawson, and C. Dymond (Newcastle), G. C. White (Sunderland), D. C. Watson, E. Swan, T. McKendrick, T. Brown and J. Wesley Brown (Middlesbrough), W. H. Loveridge (West Hartlepool), and A. L. Robinson (Stockton).

Applications for Patents.

Atkinson, A. C. Heating metal-casting moulds. 15,742. October 29. (New Zealand, January 26.)
Barfield, E. P., and Wild, L. W. Indicating condition of steel, iron, etc., magnetisable metal during heat treatment. 16,072. November 3.
Baur, C. H. vom. Electric furnace. 16,507. November 10.
Bloxam, A. G. (*Stabilimenti Biak—Ing. A. Pouchain*). Electric furnaces for melting metals. 15,745. October 29.
Coley, H. E., and Wilbraham, E. C. B. Manufacture of metallic alloys. 15,828. October 30.
Craig, T. J. I., and Spence & Sons, P. Manufacture of chromium and iron compounds. 15,581. October 26.
Crookes, Roberts & Company, and Hodgson, L. S. Metallic alloy. 15,571. October 26.
Davies, Z. Gas valves for steel-smelting furnaces. 16,273. November 7.
Dickson, H. C., and Nicklin, J. B. Manufacture of steel. 16,512. November 10.
Hunt, G. B. Casting-moulds. 15,852. October 31.
Meek, J. W. Dealing with products of combustion from furnaces. 15,413. October 23.
Metalloids, Ltd., and Perry, F. Annealing, etc., metal articles. 15,396. October 23.
McDougall, R. F., and Macintosh, R. D. Means for turning moulds in boxes, cores, etc. 15,895. October 31.
Mottram, G. W. Method of treating silica, etc., for use in manufacture of refractory goods. 16,225. November 7.
Mottram, G. W. Process for manufacture of refractory goods. 16,229. November 7.
Oubridge, W. A. Casting-machines. 15,502. October 25.
Prentice, N. Electric furnaces. 16,145. November 5.
Rayment, H. W. Device for measuring metals, etc. 15,128. October 18.
Renison, M. A. Aluminium alloy. 16,519. November 10.
Romanes, J. S. Electric furnaces for smelting and refining steel. 15,097. October 18.
Spence, H., Spence & Sons, P., and Wrigley, H. Preparation of titanium compounds. 14,950. October 16.
Smallwood, A. Furnaces for annealing, hardening, quenching, or like heat treatment of metals, etc. 16,159. November 5.
Stabilimenti Biak—Ing. A. Pouchain. Manufacture of metal alloys. 16,129. November 5. (Italy, October 23, 1916.)
Stabilimenti Biak—Ing. A. Pouchain. Copper alloys. 16,130. November 5. (Italy, October 23, 1916.)
Stabilimenti Biak—Ing. A. Pouchain. Manufacture of metal alloys containing nickel. 16,131. November 5. (Italy, October 23, 1916.)
Turner, W. L. Manufacture of steel or ferro-alloys. 15,858. October 31.

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LONDON AND BIRMINGHAM.

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Weyborn Engineering Company, Limited. — Capital £15,000 in £1 shares.

A. L. Dalton, Limited.—Capital £5,000 in £1 shares, to carry on the business of engineers, etc.

Wessex Aircraft & Shipbuilding Company, Limited.—Capital £55,000, in £1 shares (25,000 preference).

Automatic Grinding, Limited.—Capital £1,000 in £1 shares. Registered office :—45, Bank Street, Sheffield.

Wilson, Copley & Company, Limited. — Capital £15,000 in £1 shares, to carry on the business of engineers.

Chappell Pudney & Company, Limited.—Capital £6,000 in £1 shares, to carry on the business of engineers, etc.

Newcys Motor and Munitions Company, Limited.—Capital £20,000 in £1 shares. Registered offices :—77-81, Bristol Street, Birmingham.

Crawley Agrimotor Company, Limited.—Capital £20,000 in £5 shares. Registered offices : Tower Works, Mandeville Road, Saffron Walden.

Amalgamated Foundries, Limited.—Capital £5,500 in 4,000 7 per cent. non-cumulative participating preference, and 1,500 ordinary shares of £1 each.

Rustless Iron (Cowper-Coles Process), Limited.—Capital £5,500 in 5,000 7½ per cent. cum. pref. shares of £1 each, and 10,000 ord. shares of 1s. each.

Whitehouse and Pendleton, Limited.—Capital £1,000 in £1 shares, to carry on the business of iron and steel merchants. Registered office : 12, Cherry Street, Birmingham.

H. G. Norton & Company (1917), Limited.—Capital £5,000 in £1 shares, to carry on the business of engineers, etc. Registered office :—416, High Street, Cheltenham.

Neville Foundry Company, Limited.—Capital, £2,000 in £1 shares. The first directors are J. Hawkins and G. Rawlings. Registered office :—Neville Street, Rotherham.

Campbeltown Shipbuilding Company, Limited.—Capital £60,000 in shares of £10 each, to acquire the existing business. Registered office :—Trench Point, Campbeltown.

Frost Ferro-Concrete Company, Limited. — Capital £1,200 in £1 shares, to adopt an agreement with P. B. Frost. The first directors are P. B. Frost, S. Barratt, C. Croxford, and W. Mountcastle.

Thomas Ward Engineering Company, Limited.—Capital £6,250 in 5,000 preference shares of £1 each and 5,000 ordinary shares of 5s. each. Registered office, 134, High Road, New Southgate.

The Larne Shipbuilding Company, Limited.—Capital £30,000 in £1 shares, to take over the business of the Larne Shipbuilding Company, Larne. Registered office : 50, Wellington Street, Glasgow.

A. P. Newall & Company, Limited.—Capital £10,000 in £1 shares, to carry on the business of general merchants and of engineers and machine toolmakers, etc. Registered offices : 50, Wellington Street, Glasgow.

United Shipbuilders & Repairers, Limited.—Capital £2,000 (1,800 7 per cent. cum. pref. shares of £1 and 4,000 founders' shares of 1s.), to adopt an agreement with W. C. L. Lamot, E. C. Frateur, and H. F. Panesi.

Hannay & Clarke, Limited.—Capital £10,000 in £1 shares, to take over business of iron brokers and commission merchants carried on by J. E. H. Clarke, at 90, Duke Street, Barrow-in-Furness, as Hannay & Clarke.

David Adams & Sons, Limited.—Capital £4,000 in £1 shares, to carry on the business of ironfounders, engineers, etc. Secretary, D. B. Adams. Registered office :—Nelson Anchor Works, Cradley Road, Cradley Heath.

Montreal Estates, Limited.—Capital £12,000 in £1 shares, to work the Montreal and Keekle Grove Estates, and to carry on the business of ironmasters, etc. The first directors are H. D. G. Parkin, I. U. Parkin, A. D. Parkin, and Frances Henrietta Parkin. Registered office :—9, King Street, Maidstone.

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are always successful in the struggle for the Mastery of the Air

Ventilation of Ships, Buildings and Mines, Induced Draught on Boilers, Dust Removal, High Pressure Fans for Forge Fires and Cupolas, Air Washers for Cooling and Purifying the Air, Fans for Removing Fumes or Steam, Steam Heater Units for Heating Factories and Workshops.

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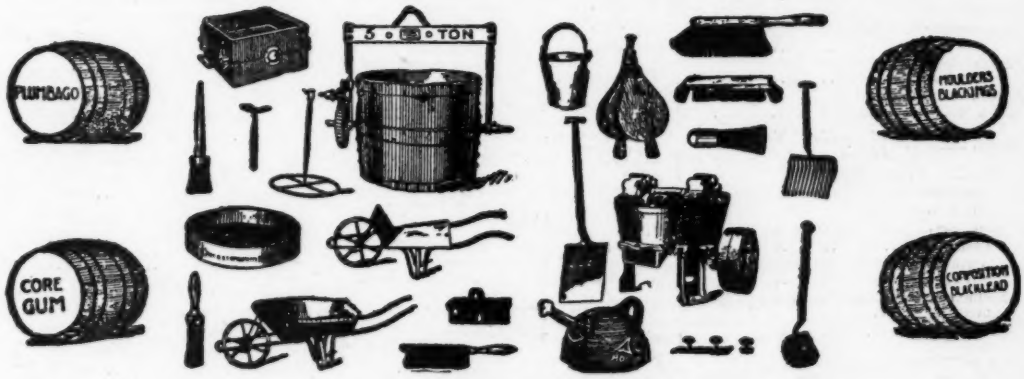
Phœnix Works, Penistone, Near Sheffield.



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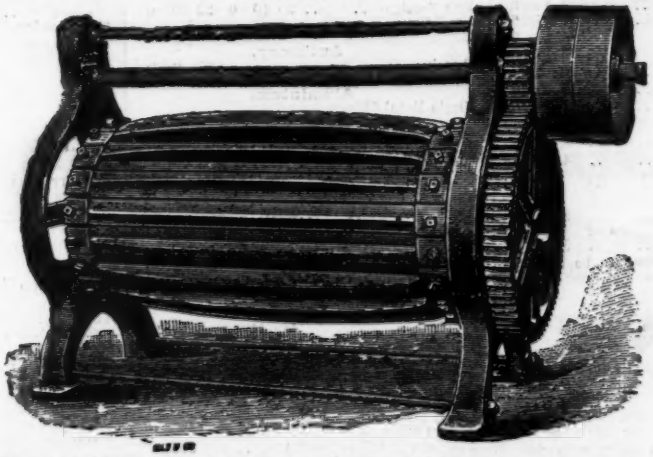

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Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

CONTROL PRICES.

Pig-Iron.

	£	s.	d.
West Coast hematite, mixed Nos. 1, 2 and 3	6	7	6
Special under 0.03 P. & S... ..	6	15	6
" " 0.02 "	7	0	0
East Coast hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.04 P. & S. ..	6	7	6
Special under 0.03 P & S. ..	6	15	6
" " 0.02 "	7	0	0
Scotch hematite, mixed Nos. 1, 2 and 3..	6	2	6
Special under 0.03 P. & S. ..	7	10	0
Welsh hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.03 P. & S. ..	6	15	6
" " 0.02 "	7	0	0
HEMATITE—MALLEABLE— Refined—			
Refined Cupola Cast	8	0	0
Refined Cupola Cast to guaranteed analysis..	8	5	0
Cast direct from Blast Furnaces—			
Small Pig-Iron, all grades ..	7	10	0
Medium Pig-Iron White to Grey mottled	7	5	0
Medium Pig-Iron, all other qualities	6	17	6
Large Pig-Iron, all grades ..	6	17	6
Lincolnshire, basic or foundry ..	4	12	6
Cleveland, No. 1	4	11	6
" other grades	4	7	6
" basic	4	17	6
Northamptonshire, forge	4	7	6
" fdy numbers	89/0		94/0
" basic	4	17	6
Derbyshire, forge	4	10	0
" foundry numbers	92/6		96/6
Derby & Notts. basic.	4	17	6
Leicestershire & Notts., forge ..	4	10	0
" " foundry nos.	92/6		96/6
North Staffs, forge	4	15	0
" " foundry	4	17	6
" " basic	4	17	6
South Staffordshire— Part mine forge	4	15	0
" foundry	4	17	6
Common Staffordshire ..	4	10	0
All mine forge	5	15	0
" foundry	6	0	0
Warm air forge	7	5	0
" foundry	7	15	0
Lord Dudley's silicon	8	7	6
Cold blast	9	2	6
Basic	4	17	6
Scotch foundry and forge— Nos. 3, 4, and lower grades of Monkland, Dalmellington, Eglinton, and Govan.. ..	5	14	0
Nos. 3, 4, and lower grades of all other brands	5	15	6

No. 1 quality in all cases to be 5s. per ton above these prices.

All per ton net, f.o.t. makers' works. Mers. Com. 1½%

In all districts 1s. extra may be charged for Basic cast in chills.

High-Speed Tool Steel.

The maximum prices for high-speed tool steel have been fixed as follows:—

Finished bars, 14% Tung. 2s. 10d.

Finished bars, 18% Tung. 3s. 10d.

Per lb. basis. Extras as per authorised list. These prices are not delivered buyers' works.

The fixed prices for scrap which must be returned to steel makers' works are as follows:—

Millings and Turnings	5d.
Bar Ends	6d.

Both per lb. net delivered steel makers' works.

Ferro-Alloys

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome: 4/6% carbon. Basis 60%, scale 10s. per unit Per ton	—		
Ferro-chrome: 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	—		
Ferro-chrome: 8/10% carbon. Basis 60% scale, 10s. per unit Per ton	—		
Ferro-chrome: Specially refined, guaranteed maximum 2% carbon broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton	—		
Ferro-vanadium: 33/40% Va., per lb. of Va. contained in the alloy	—		
Ferro-silicon: 45/50%. Basis 50%, 5s. scale per unit .. Per ton	—		
Ferro-titanium: 23/25%, per lb. carbonless..	—		
Ferro-molybdenum: 70/80% Mo. per pound of Mo. contained ..	—		
Ferro-phosphorus: 20/25%. Per ton	—		
Ferro-tungsten: 75% to 80% per lb. of metallic tungsten contained	—		
*Ferro-manganese 80%	25	0	0
" export £36 0 0—39	0	0	

* F.o.b. Liverpool.

Non-Ferrous Metals.

	£	s.	d.	£	s.	d.
Copper.						
Standard, Cash	..110	0	0	110	10	0
Three months	..110	0	0	110	10	0
Electrolytic ..	..125	0	0	121	0	0
Tough ..	..123	0	0	119	0	0
Best selected ..	..123	0	0	119	0	0
Tin.						
Standard, Cash	..291	0	0	291	5	0
" Three months	289	5	0	289	10	0
English Ingots ..				291	0	0
Bars		—		292	0	0
Refined		—			—	
Spelter.						
American	54	0	0	50	0	0
Specials..		—			—	
Hard		—		45	0	0
British	56	10	0	57	0	0
Lead.						
Soft Foreign ..	20	10	0	29	10	0
English		—			Nom.	
Antimony.						
Regulus		—		85	0	0
Aluminium.						
Virgin Metal 98/99% per ton		—			—	

Phosphor Bronze.

INGOTS.	Per ton.
Alloy No. I. or II	—
III., IV. or V.	—
VI. or VII.	—
VIII.	—
XI.	—
Cast Strips and Ingots.. ..	—
CASTINGS.	**Per lb.**
I. or II.	—
III. IV. & V.	—
VI. or VII	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid ..	—
" Cored Bars	—

Delivery 2 Cwt. free to any town.

10 per cent. Phosphor Copper .. price of best selected copper.	£50 above
15 per cent. Phosphor Copper .. price B.S.	£70 above
Phosphor Tin (5 per cent.) .. price of English Ingots.	£30 above

(Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FARNLEY STREET MILLS, BIRMINGHAM).

***Chromium (Metallic).**		
98/99% purity, per lb.	—	—
***Nickel.**		
In cubes, 98/99% purity Per ton		—

Nickel Silver.

	per lb.
Ingots for raising	—
Ingots for Spoons and Forks ..	—
" rolled to spoon size ..	—

***Tungsten Metal Powder.**

96/98% purity.. per lb. ..	—

***Molybdenum Metal.**

96/98% purity.. per lb. ..	—

***Cobalt Metal.**

97% purity .. per lb. ..	—

Quicksilver.

75 lb. bottle	—

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

	Cleveland. s.	d.	s.	d.
Steel scrap, heavy melting..	105	0	—	
Iron scrap cast (cupola metal)	90	0	95	0
London (f.o.b.).				
Heavy steel			105	0
Light "			55	0
Heavy cast			95	0
Control Prices.				
Heavy Steel Melting Scrap	105	0	125	0
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Metals.	Tons.
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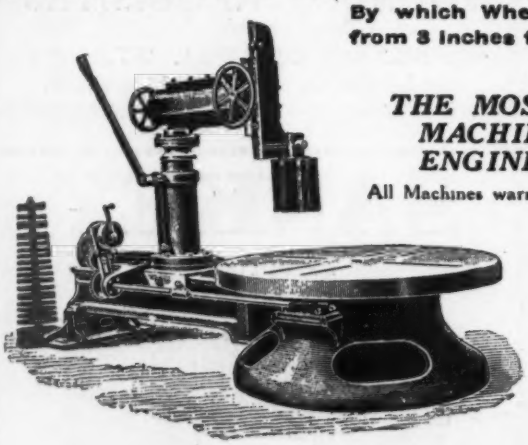

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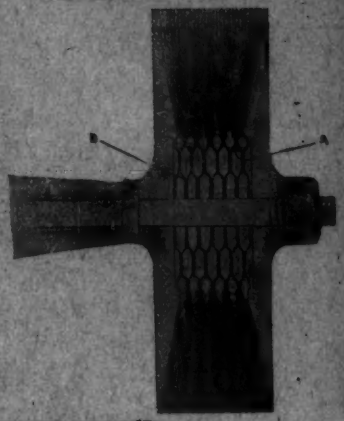

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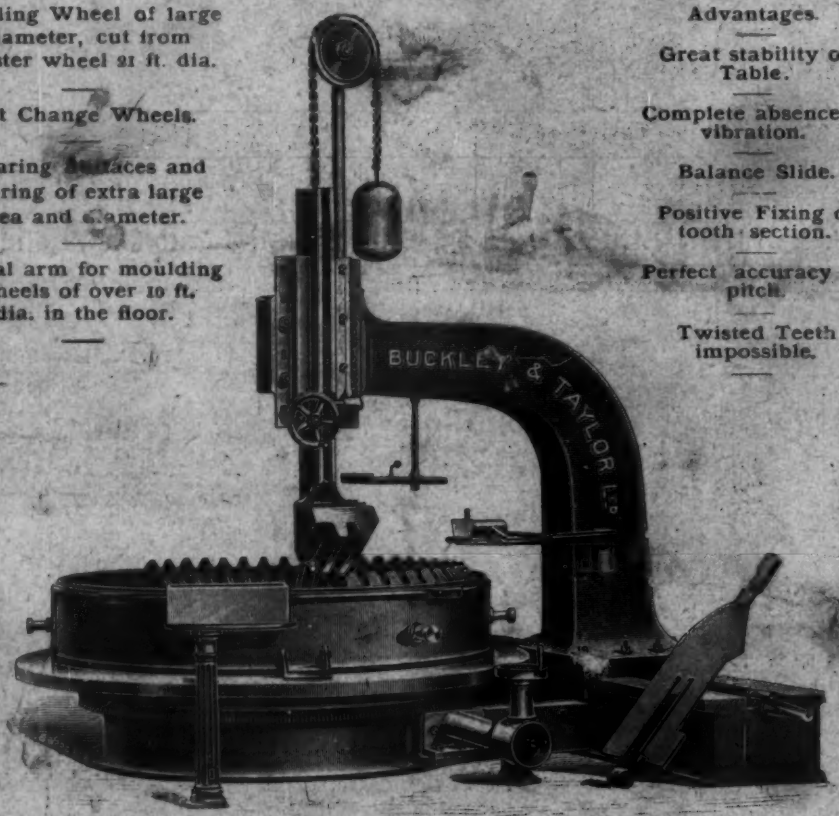

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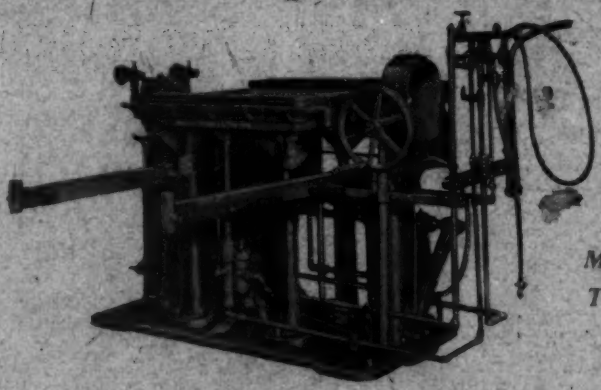

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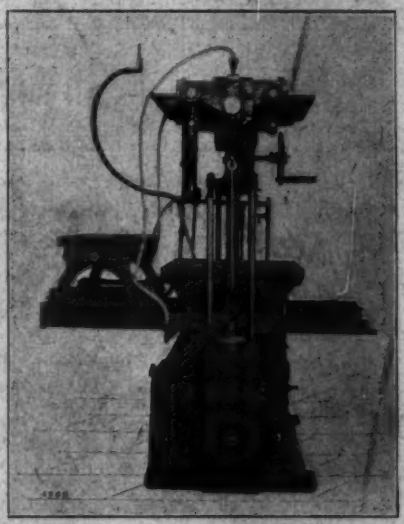

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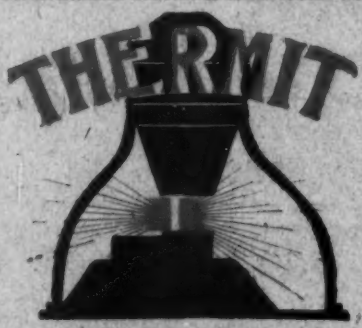

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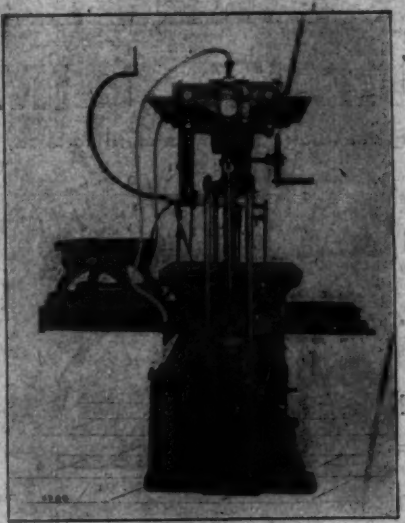

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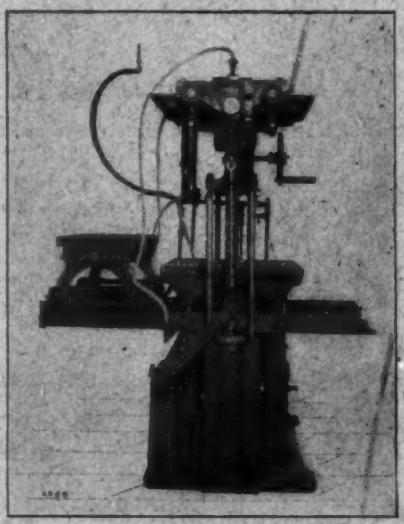

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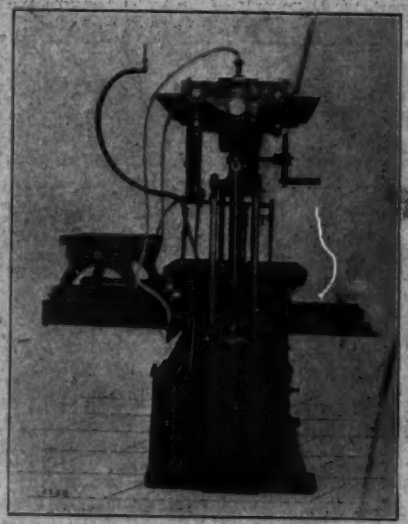

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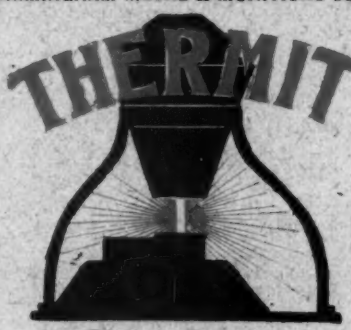

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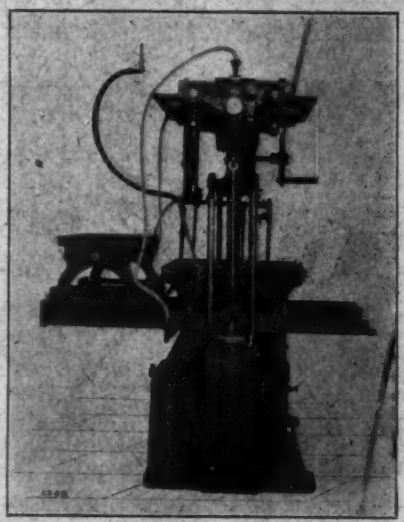

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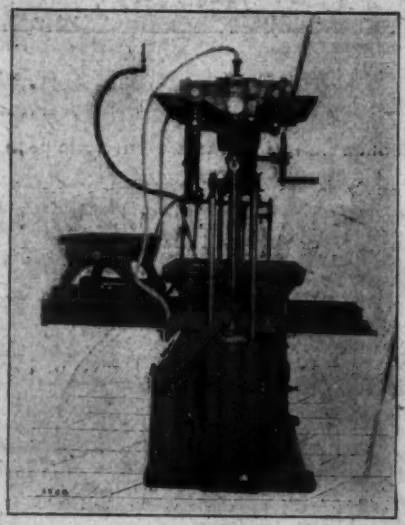

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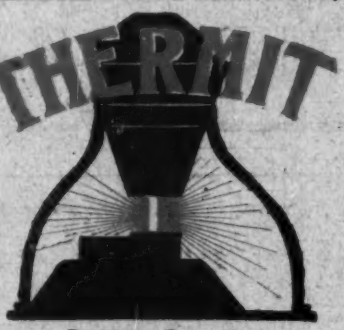

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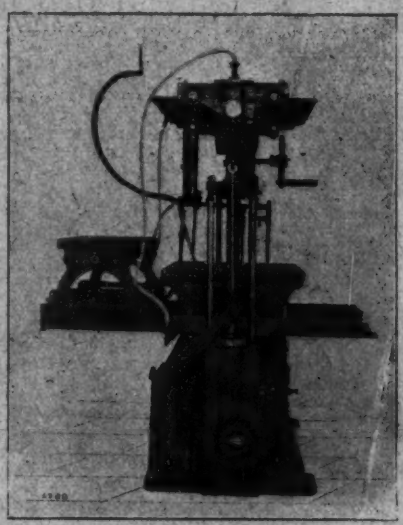

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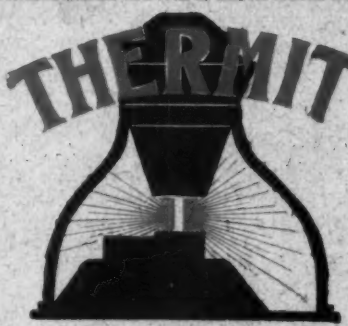

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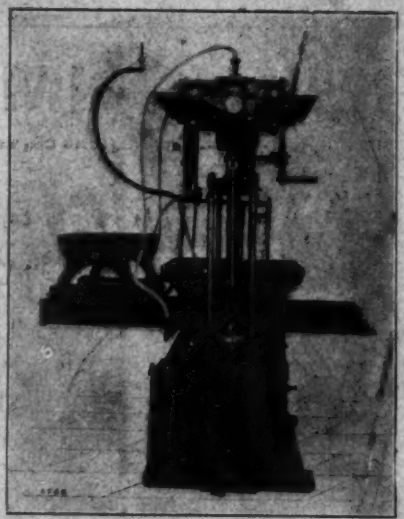

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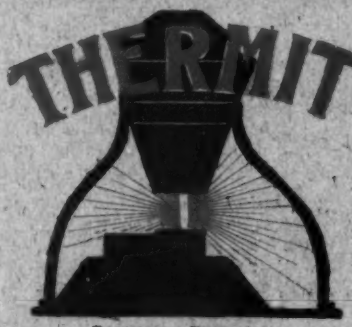

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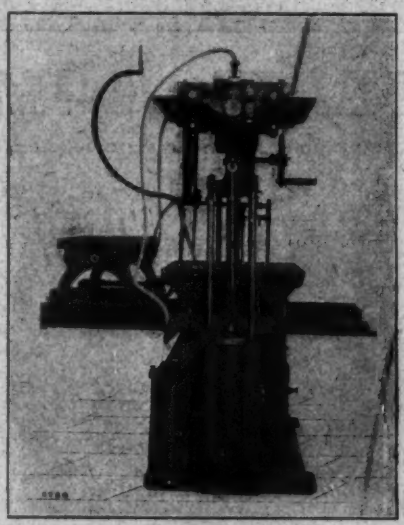

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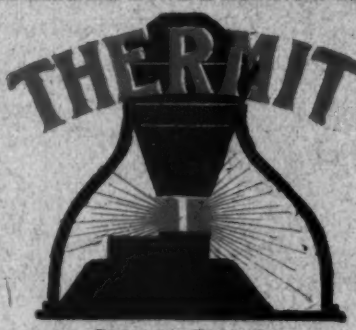

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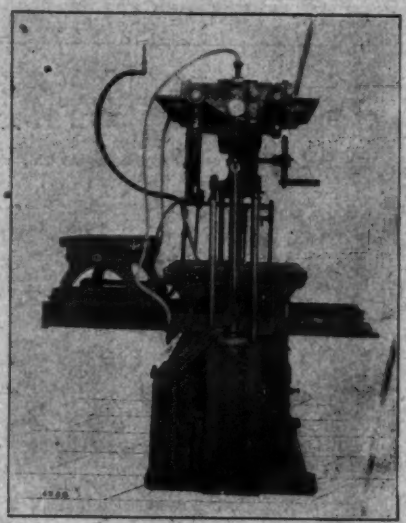

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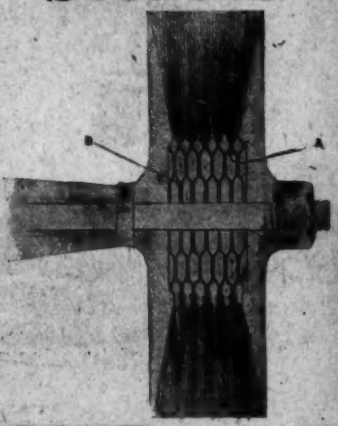

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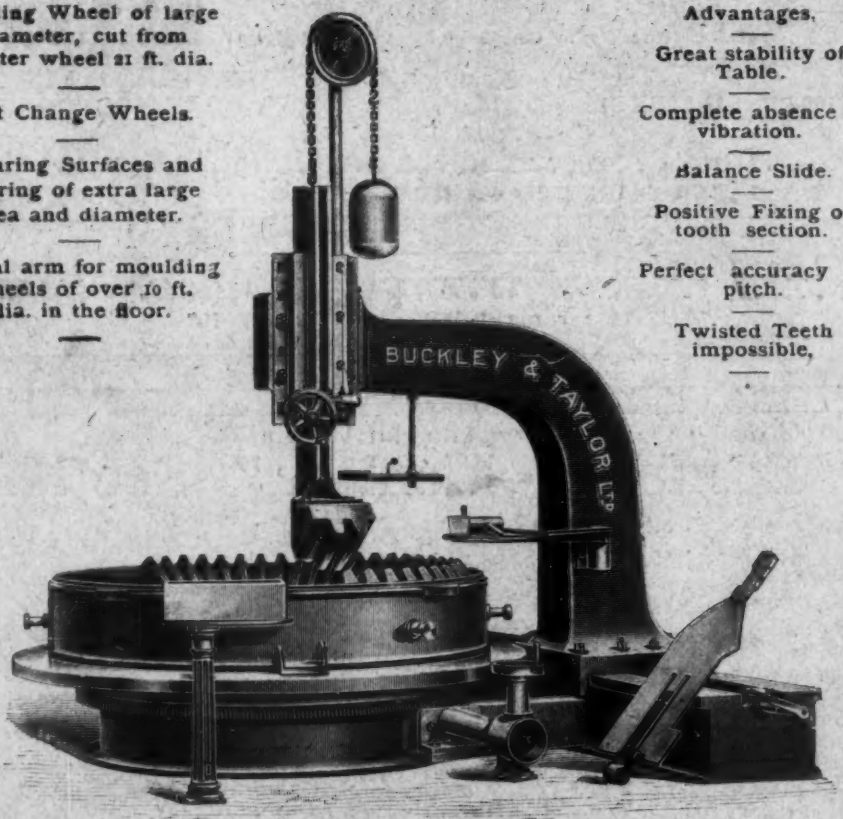

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